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The role of small actors in renewable energy auctions

Master's Thesis

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Abstract of master's thesis

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Abstract

The energy production sector is one of the main polluters in the world and thus plays a significant role in emission reductions and climate change mitigation. All the time more renewable energy production is needed to replace fossil fuel power plants. However, renewable energy is still in the most cases more expensive than conventional energy production and thus has to be supported financially in order to reach the renewable energy targets and a more environmentally friendly energy sector.

This master's thesis discusses renewable energy auctions and the role of small actors in them. Renewable energy auctions are a renewable energy support method, which is in use in an increasing number of countries in the world. These auctions set the remuneration level offered for renewable energy producers competitively, that is only the producers winning the auctions receive the support. The competitiveness requires the producers to develop the technologies in order to reduce costs and therefore increase the possibilities to be successful in the auctions. The advantage of this support method is its feature of driving down the costs caused by renewable subsidies to the society.

Because of the competitive characteristics of the renewable energy auctions, small actors often have disadvantages in this support method as they are not able to offer renewable projects as cheaply as large actors in many cases. Therefore, if this issue is not considered when implementing the auctions, small actors might disappear from the renewable energy markets. This thesis analyses renewable energy auctions in five countries, namely Germany, Denmark, France, the Netherlands and Brazil, in order to find the best practices to enable small actor participation in renewable energy auctions. Also a short overview on other sectors' auctions and small actors is conducted.

The most important identified factors enhancing small actor participation in the auctions are auction design simplicity, technology choice (solar photovoltaic is the most suitable technology), low financial requirements and risks, low work load prior to the auctions and price-only evaluation. Other sectors' auctions show that also some exception rules for small actors are possible when carefully designed.

Keywords renewable energy support, feed-in tariff, competitive tariff setting, actor diversity, cost efficiency, auction design, acceptability

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Tiivistelmä

Energiantuotantosektori on yksi suurimmista ilmaston saastuttajista ja siksi ratkaisevassa asemassa päästöjen vähentämisessä ja ilmastonmuutoksen hillitsemisessä. Uusiutuvan energian tuotantoa tarvitaan yhä enemmän korvaamaan fossiilisilla energianlähteillä toimivia voimalaitoksia. Uusiutuva energia on kuitenkin yhä edelleen usein kalliimpaa kuin uusiutumaton energia ja sen takia tarvitsee rahallista tukea, jotta uusiutuvan energian lisäystavoitteet saavutetaan ja energiasektori muuttuu ympäristöystävällisemmäksi.

Tämä diplomityö tarkastelee uusiutuvan energian huutokauppoja ja pienten toimijoiden roolia. Uusiutuvan energian huutokauppa on uusiutuvan energian tukimuoto, jota käytetään yhä useammassa maassa. Huutokauppa asettaa uusiutuvalle energialle tarjotun tuen määrän kilpailun avulla, eli vain tuottajat, jotka voittavat huutokaupan, saavat tuen. Tämä vaatii tuottajia kehittämään teknologiaa saavuttaakseen matalammat kustannukset ja näin paremmat voittomahdollisuudet huutokaupassa. Tämän tukimuodon etu on sen kyky ajaa uusiutuvasta energiasta yhteiskunnalle aiheutuvia tukikustannuksia alas.

Huutokaupan kilpailuhenkisyys saattaa kuitenkin usein pienet toimijat huonompaan asemaan, koska ne eivät pysty tarjoamaan yhtä edullisia projekteja kuin suuret toimijat. Jos tätä ei oteta huomioon huutokauppaa suunnitellessa, saattavat pienet toimijat kadota uusiutuvan energian markkinoilta. Tämä diplomityö analysoi uusiutuvan energian huutokauppoja viidessä maassa, Saksassa, Tanskassa, Ranskassa, Alankomaissa ja Brasiliassa, jotta parhaat tavat pienten toimijoiden kannustamiseen huutokauppoihin osallistumisessa voitaisiin tunnistaa. Lisäksi lyhyt katsaus muiden sektoreiden huutokauppoihin ja pieniin toimijoihin tuo lisää näkökulmaa aiheeseen.

Tärkeimmät tunnistetut tekijät, jotka auttavat pieniä toimijoita huutokauppaan osallistumisessa, ovat huutokaupan sääntöjen yksinkertaisuus, aurinkokennot teknologiana, pienet taloudelliset vaatimukset ja riskit, pieni työpanos ennen huutokauppaa ja tarjouksen hinta ainoana arvostelukriteerinä. Muiden sektoreiden tarkastelu paljastaa, että joissain tapauksissa myös poikkeussääntöjen luominen pienille toimijoille on kannattavaa, kun ne suunnitellaan huolella.

Avainsanat uusituvan energian tuki, syöttötariffi, tariffin asettaminen kilpailulla, toimijoiden moninaisuus, kustannustehokkuus, huutokaupan design, hyväksyttävyys

Preface

This master's thesis has been a challenging but interesting project. My understanding on renewable energy support schemes has increased a lot. The problems but also wide possibilities related to the renewable energy support now appear to me much more as a wholeness and that knowledge will certainly help me further in a professional sense. During the writing of this thesis, my awareness of the significance of the climate issues and environmental friendliness has grown further and will for its part also affect my decisions both in professional and private life into even more environmental friendly direction.

I would like to thank my advisor Marijke Welisch and her supervisor Gustav Resch for the idea to the interesting topic of my thesis. They also gave me valuable insights, literature tips and advice throughout the whole project. I would also like to thank my supervisor Sanna Syri, who gave me feedback both in details and wider aspects of my thesis and helped me through this project with her firm academic and professional experience.

I would also like to express my gratitude to my family for supporting and encouraging me through my studies and always helping me with smaller and bigger problems. Special thanks belong to my boyfriend Philipp, who has been supporting and helping me during this challenging project.

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Jenni Lairila

Contents

Abbreviations

CCEE	Chamber for Commercialisation of Electrical Energy (Brazil)
CHP	Combined Heat and Power
CO_2	Carbon dioxide
CRE	Energy Regulation Commission (France, Commission de régulation de l’énergie)
EEG	Renewable Energy Sources Act (Germany, Erneuerbare-Energien-Gesetz)
EU	European Union
GW	Gigawatt
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
kW	Kilowatt
kWh	Kilowatt-hour
MW	Megawatt
MWh	Megawatt-hour
NREAP	National Renewable Energy Action Plan (France)
PPI	Multiannual Programming of Investment (France, Programmation Pluriannuelle des Investissements)
PV	Photovoltaic
SDE	Sustainable Energy Incentive Scheme (The Netherlands, Stimulering Duurzame Energieproductie)

1 Introduction

During the last decades it has become clear that in order to reduce the negative effects of climate change, it is crucial to increase the amount of renewable energy sources in energy production. The Intergovernmental Panel on Climate Change (IPCC) has stated in its reports about climate change, and especially in the newest Synthesis Report *(2014)*, that the changes in the climate and its warming over the last decades is inevitably happening and it is not a natural change. The data from over the last one hundred years show an increase of 0,85 °C in the average land and ocean surface temperature from the year 1880 to the year 2012. The reason for the temperature increase is the higher percentage of greenhouse gases (especially carbon dioxide, methane and nitrous oxide) in the atmosphere. The experts agree widely that at least a (relatively large) part of the global warming is caused by human actions. Therefore, reverse human actions can also limit the further climate change – indeed, the IPCC goal is to keep the global warming in maximum 2 °C of the pre-industrialization level. This way the already identified negative effects of climate change, such as extreme weather phenomena, heat waves, ice melting in the Arctic regions and higher precipitation, can be limited to minimum. *(IPCC, 2014)*

The energy sector is one of the largest emission producers in the world and thus one of the most important sectors to increase its climate-friendliness to slow down the climate change. According to International Energy Agency (IEA), energy production and use covers two thirds of all the greenhouse gas emissions in the world. Thus, it is clear that it is crucial for the energy sector to reduce its emissions in order to reach the climate goals. IEA has defined measures to cut down the emissions of energy production. The measures include phasing out least-efficient coal-fired power plants, stopping fossil-fuel subsidies and increasing significantly investments made on renewable energy. As can clearly be seen from the measures, renewable energy plays a critical role in reducing the effect of climate change. *(IEA, 2015)*

IPCC *(2011)* has defined renewable energy as “any form of energy from solar, geophysical or biological sources that is replenished by natural processes at a rate that equals or exceeds its rate of use”. The most used and known renewable energy sources are biomass, solar energy, wind energy, geothermal energy, hydro power, tide and waves and ocean thermal energy. Some of the mentioned renewable energy sources are not automatically renewable, but the classification depends on the usage rate – it is for example possible to use biomass (e.g. wood) more than the growing rate is. Renewable energy sources as such have also either zero (e.g. hydro and solar) or neutral (e.g. biomass, where the emissions emitted by using biomass as a fuel are absorbed in the growing biomass) greenhouse gas emissions when not taking into account the equipment needed to harness the energy. *(IPCC, 2011)*

Most of the projects that base on renewable energy sources, however, have high initial investment costs, partly because of their novelty, and can therefore not compete with conventional power plants with prices. This makes many renewable energy sources economically unfeasible as such, without well-planned support mechanisms. Thus, governments in many countries have implemented one or more systems to create incentives for renewable energy projects. *(Sawin, 2004; Kylili & Fokaides, 2015)* The most-used direct renewable support systems are feed-in tariffs or premiums, tradable green certificates and competitive tariff setting mechanisms, i.e. auctions *(Kylili & Fokaides, 2015; del Río & Linares, 2014)*. Also investment support methods like tax incentives, investment grants or low-interest loans are used to support renewable energy *(Sawin, 2004)*.

Feed-in tariffs or premiums guarantee a sufficient electricity price for renewable energy producers to be able to cover the investment costs. Feed-in tariff sets a fixed price the producer is paid per produced electricity unit and feed-in premium is a premium paid additionally on the top of the market price. Both have normally a fixed contract period during which the tariff or premium is paid, and different technologies have different feed-in amounts. *(Sawin, 2004)* The feed-in systems, when designed and implemented properly, have proven to be a good incentive for a fast increase of renewable energy. It also encourages to build many different kind of renewable technologies, including the more expensive or immature technologies, as all the technologies have a support amount suitable for that exact technology. However, too high remuneration level is possible to occur in feed-in systems, causing unnecessary costs to the society and not incentivising the producers to develop the most efficient systems. *(Hirvonen et al., 2015)*

Under tradable green certificate systems, the government obliges the energy suppliers to produce a certain percentage of their energy production with renewable energy sources. The suppliers obtain so-called green certificates according to the required amount. If a supplier has more renewable energy production than entitled, the extra certificates can be sold, and accordingly, a supplier not complying the required amount can buy these certificates. *(Casisi et al., 2015)* The certificate price is normally determined by the market, but the government can also set a maximum or minimum price. With a tradable green certificate system, the costs for society are likely to be lower than with feed-in systems, as the market decides the price. However, the government deciding the obligated percentage of renewable energy might also limit the renewable energy increase, if the percentage is set too low when considering the country's renewable potential. It also tends to prefer the cheaper renewable technologies, as the certificate price is the same for all different technologies. *(Sawin, 2004)*

Investment supports for renewable energy help the producers in the beginning of the renewable energy project. The government can support the initial investment for example by a direct grant to the producer to cover some of the initial costs, offer tax reliefs or lower the interest rate of the investment loan. *(Sawin, 2004)* However, the investment support methods do not create an incentive to the suppliers to produce as much energy as they can with the renewables, and additionally cause large expenses at a certain time to the government, as the whole support is paid at once. Therefore, production based support methods are in many countries nowadays preferred. *(Hirvonen et al., 2015)*

Renewable energy auctions are a relatively new renewable support method. In this method, the support price is set competitively by an auction, in which the market actors, who want to produce renewable energy, can take part. This way the support level is determined by the market. Most of the other renewable support methods involve government or other regulatory body decision on the support price needed. *(Sawin, 2004)* However, the regulatory body is not an active market player, and thus does not know the costs and profits of renewable energy production as accurately as the actual market players. This might lead to either very high renewable support costs, which in the end fall to the society, either to the tax payers or to the electricity consumers, or too low support, in which case not enough new renewable capacity is built. As constantly more renewable energy should be implemented in order to limit the climate change, the renewable support costs rise inevitably. Therefore, it is necessary to look for support methods minimizing the costs and maximizing the efficiency. Renewable energy auctions, when designed carefully, would offer a solution to this problem. *(del Río & Linares, 2014; Fraunhofer ISI et al., 2014)*

European Union (EU) has defined in its Directive 2009/28/EC that it will have 20% of the energy consumption of the member countries produced with renewable energy sources by 2020 *(European Council, 2009)*. Additionally, the policy framework of the European Commission for the period from 2020 to 2030 sets the renewable energy target for 2030 to be at least 27% of the energy consumption *(European Commission, 2014a)*. To be able to achieve these goals, all the member countries have to use support instruments for promoting renewable energy. EU will require, according to the Energy and Environment State Aid Guidelines of the European Commission, in order to unify the support mechanisms used in the member countries, that every member country takes renewable energy auctions as their support instrument at the latest in 2017. Some exceptions to this requirement are, however, allowed, for example to avoid rising support costs or not to exclude small actors from the markets. *(European Commission, 2014b)*

Thus, renewable energy auctions are a relevant and actual topic in both global and European contexts. As already mentioned, EU member countries, when implementing auctions, are allowed to make an exception with small actors. From this, it can be concluded that there might be some problems with small actor participation in the auctions. Indeed, as auction is a competitive procedure, large actors, for example international companies, are able to use their economies-of-scale effect to influence the prices, an advantage that small actors do not have, and thus small actors might therefore easily be discriminated in the auctions *(del Río & Linares, 2014; Sawin, 2004)*. This master's thesis researches the role of small actors in renewable energy auctions. The goal is to find out the best practices to attract small actors to participate in the renewable energy auctions and to enable them to bid successfully. However, this thesis does not concentrate on the options of excepting small actors from the auctions as a whole and offering them some alternative support methods. The research is conducted by a literature review over five countries, Germany, Denmark, France, the Netherlands and Brazil, which have implemented renewable energy auctions, and an extensive qualitative analysis on the outcomes of the literature review. The analysis compares the design of the renewable auctions in the five countries, finds common elements and features to promote small actors and discusses the found features in the renewable energy market structure context of each country. Additionally, a short review on auctions in other sectors than renewable energy is conducted and the methods for small actor participation enhancement analysed. By these means, this thesis finds the best practices for small actor promotion in the renewable energy auctions based on the experiences of the five countries.

This thesis consists of seven chapters. After this introduction, the second chapter presents renewable energy auctions, describes them in detail and gives a short overview of auction theory. Chapter 3 discusses the problems and advantages of small actor inclusion in the auctions, presents ways to define a small actor and shortly describes the small actor support possibilities if they are excluded from the auctions. In chapter 4, the literature reviews of Germany, Denmark, France, the Netherlands and Brazil is conducted. The literature reviews discuss the general renewable energy situation in each country, the implementation features of the renewable energy auctions, how small actors are taken into account in the auctions and if the auctions have been attractive to them and also offered possibilities to win for small actors. The fifth chapter compares the experiences and the sixth chapter presents perspectives to the topic from other sectors' auctions. Finally, chapter 7 concludes the thesis.

2 Renewable energy auctions

2.1 Introduction to renewable energy auctions

Renewable energy auctions are a renewable energy support mechanism, which base on the idea of regulatory body deciding the necessary or wanted renewable capacity increase and the market to decide the price for the demanded increase. Ideally, this system would mirror the real costs of renewable energy production and thus cause the minimum support costs for the society. Auction process also releases the regulatory body from trying to estimate the real costs of renewable energy projects and instead lets the project developers, who know the costs best, decide the costs and thus the support levels. *(Kylili & Fokaides, 2015)* Auction process can also be called as bidding or tendering process *(del Río & Linares, 2014)* and therefore the three terms are used in this thesis interchangeably.

To start a renewable energy auction, regulatory body publishes a call for tenders. In the call for example the rules, agreement conditions, capacity available for tendering and other necessary terms are defined. After the call for tenders, producers or suppliers are allowed to submit their tenders. In theory, all possible actors from small co-operatives to large, international companies can bid with their offer(s). The bid price is the amount of support with which the bidder can realize the project. The support is normally in terms of price per capacity unit or per produced energy unit, thus being basically a type of feed-in tariff, just the amount of the tariff is decided by the market. *(Kylili & Fokaides, 2015; Fraunhofer ISI et al., 2014)*

After the tenders are submitted, the auctioneer, i.e. the regulatory body, organises the bids in the order of increasing price. The bids, starting from the lowest price, are awarded the rights to realise the projects and get the bid support, until the desired volume (or in some cases the price limit) is reached. The rest of the bids are neglected. The support will be contracted for the winning bids for a certain period of time (normally relatively long time, e.g. 10-20 years). In the most cases, the support level defined in the auction, i.e. the price that the producer receives from the regulatory body, is the price difference between the higher, in the auction fixed support level and the lower, electricity market spot price. *(Sawin, 2004; Kylili & Fokaides, 2015)*

The presented flow of the auction is a general, simplified model to understand the principle of the renewable energy auctions. However, the real, detailed flow of an auction can vary a lot from country to country and even inside a country from auction to auction. This is because of the large amount of auction design elements and their many possible ways of design. *(del Río & Linares, 2014)* The design elements and their effect on the auctions are explained more in detail in the subchapter 2.3 Auction design elements.

By setting up the auction and deciding the desired capacity increase, the regulatory body or the state's government usually has a long-time target for renewable energy capacity. This, indeed, is one of the main drivers for implementing auctions as a renewable energy support method. When the government can decide the auctioned volumes of renewable capacities, it is easy, in theory, to achieve the renewable targets in the decided or given time frame.

(Sawin, 2004) As the projects and developers have to compete with each other, they have the pressure to reveal the real costs of producing energy with a specific renewable energy source, thus minimizing the unnecessary or too high profits. Thus, the main goal of the auctions is to reach the desired renewable capacity level with the minimum costs to the society. *(Kylili & Fokaides, 2015)*

Renewable energy auctions have already been implemented in a number of countries, and therefore there are already some experiences of the functioning of the auctions. Some experiences in the late 1990's and early 2000's from auctions that can be described as failed, in sense of cost-efficiency and the ability to implement new renewable energy projects, have been ruling the opinions about renewable energy auctions for some years. However, in the recent years, a lot of studies have been carried out proving auctions not automatically as a non-functioning instrument to promote renewable energy, but rather being very sensitive to its design affecting the outcome. *(del Río & Linares, 2014)* Indeed, the number of countries which have implemented renewable energy auctions has risen from 9 in 2009 to 44 in 2013, showing a rapid increase in the popularity of the auctions. Thus, the auctions and their possible success in implementing new renewable energy should be considered as a support method among the other successful ones. *(IRENA, 2013)*

2.2 Auction theory

To be able to understand the auction mechanisms in general and apply the principles to the renewable energy auctions, a short overview of auction theory is presented in this chapter. All the theories explained in this chapter are theories for regular auctions, where there is one seller, the auctioneer, and many buyers, the bidders, and the seller wants to achieve the highest possible price for the item auctioned. However, renewable energy auctions are reverse to this procedure and called procurement auctions. In procurement auctions there is only one buyer, which is the auctioneer, and many sellers, who are the bidders. The buyer wants to buy the auctioned item with the lowest possible price. All the regular auction theories apply to the procurement auctions as well, only reversely. *(Ausubel, 2008; Fraunhofer ISI et al., 2014)*

The simplest auction format is an auction, where a single item is auctioned and the winner is the bidder who value the item the most, i.e. bids the highest price. The winner and the according price can be determined in single-item auctions either by a closed auction format (sealed-bid auctions) or open auction method (dynamic auctions). In case of sealed-bid auctions, the price can be determined with a first-price or second-price rule. When applying sealed-bid auctions, the bidders submit their bids to the auctioneer without any information about the bids of the other bidders. After the bids are submitted, the auctioneer announces the winner bid. If first-price rule is applied, the bidder pays the price he bid, and in case of second-price rule, the price of the second-highest bid. *(Ausubel 2008)* Open auctions can have various formats. The most-known formats are open ascending and open descending auctions. Open ascending auction is the traditional auction, where the auctioneer calls a low start price, and the bidders announce their interest. The auctioneer starts to raise the price until there is only one bidder interested in the item. The last bidder wins and buys the item on the last round's price. *(Krishna, 2002)* The open ascending auction can be organised also in the way that the auctioneer does not increase the price but the bidders submit every round successively higher bids *(Ausubel, 2008)*. In open descending auction the auctioneer calls first a very high price, with which no bidder is interested to buy the item. The auctioneer lowers the price until one bidder shows interest, and the bidder buys the item with that price. *(Krishna, 2002)*

In many cases nowadays, however, the auctions are applied in situations where not only a single item is auctioned at a time but a certain amount of a good or many similar, but not identical goods are auctioned at the same time, probably allowing many bidders to be winners. Therefore, multi-item auctions and their theory are of a great importance. When the goods to be auctioned are possible to divide in parts in as large units as wanted, theory of auctions of homogeneous goods can be applied. Also here sealed-bid and open auction formats exist. The bidders submit in addition to the price they are willing to pay also the amount they want to buy with the price. In sealed-bid homogeneous goods auctions, the bids are organized as in single-item auctions, and the bidders with highest bids, until the auctioned volume is satisfied, are the winners. The price can be defined three ways: pay-as-bid, uniform or Vickrey pricing. With pay-as-bid method, the winners pay the price they bid, in uniform pricing every bidder pays the price of the lowest bid and in Vickrey auctions all the bidders pay the price of the first not-winning bid. *(Ausubel, 2008; Krishna, 2002)*

The open auction version of multi-item auctions is a so-called clock auction. The auctioneer starts either with a high or a low price and decreases or increases the price, respectively. The bidders submit each round their bids with the bid amount and price. The winners are in ascending clock auctions the ones who remain after the auctioneer has increased the price until there is no excess quantity bid, and the winners pay the price of that round. In descending clock auction the auctioneer lowers the price until there are enough bids to satisfy the auctioned quantity. A non-uniform version of dynamic homogeneous multi-item auction is Ausubel auction, where a bidder can be awarded to win already before the auction is over. If the amount bid by the rest of the bidders is less than the total auctioned quantity at an ascending clock auction round, the bidder whose bid exceeds the auctioned quantity gets the difference between the auctioned quantity and the amount bid by others already at that round, with the price of that round. On other means the auction is held as a normal clock auction. *(Ausubel, 2008; Krishna, 2002)*

When the goods auctioned cannot be divided the way as in homogeneous goods auctions, but all the goods have their own features, the multi-item heterogeneous goods auction theory applies. There are also various ways to organize heterogeneous goods auctions. *(Ausubel, 2008)* In simultaneous ascending auctions the bidders submit their bids, where they give their price for each item auctioned. The auctioneer defines a standing price for each item, and on the next round the bidders must bid higher than the standing price. The auction ends when no new bids are submitted and the last bidders with the newest standing prices buy the items with those prices. *(Milgrom, 2004)* However, there might be some synergies between the auctioned items, for example that some bidder might value getting two of the items higher than the sum of each single item, or vice versa. In this case the items are so-called complements to each other, instead of being substitutes to each other. An auction format taking this into account is static pay-as-bid combinatorial auction. In this auction format the bidders are allowed to submit bids also with packages, i.e. price for many items at the same time, not obligating them to buy only a single item. Another version of the combinatorial auctions is Vickrey-Clarke-Groves auction, where the winning bidders pay according to the more value they bring by taking part to the auctions. *(Ausubel, 2008)*

Some similarities can be found between the different auction formats. When considering bidder strategies in single-item auctions, sealed-bid first-price auctions and open descending auctions are similar. In both, the bidder has to decide prior to the auction how much he values the item. Unlike in the other dynamic auction, open ascending auction, in descending auction the bidders do not receive any information of other bidders' behaviour, and will thus strategically bid only when the price announced by the auctioneer equals to the price he prior to the auction decided. When the first bidder shows his interest, the auction is over and the other bidders will not have a chance to bid after learning from other bidders' behaviour. This similarity in bidder strategies suggests the auction outcome to be the same in the two auction models. Also single-item sealed-bid second-price and open ascending auctions have similarities, though not as strong, in bidder strategies. Accordingly, in homogeneous multi-item auctions corresponding relations can be found: descending clock auction corresponds to pay-as-bid auction, ascending clock to uniform price and Ausubel auction to Vickrey auction. *(Krishna, 2008)*

There are also relations between the theories for single-item, multi-item homogeneous goods and multi-item heterogeneous goods auctions. When pay-as-bid or descending clock auction is reduced to single-unit model, it reduces to first-price or open descending auction. Respectively, Vickrey or Ausubel auction can be reduced to second-price or open ascending auction. *(Krishna, 2002)* Vickrey-Clarke-Groves is a multi-unit heterogeneous goods auction version of the Vickrey auction of homogeneous goods, and thus also theoretically related to the single-unit second-price auction. *(Ausubel, 2008)* As can be seen, there are a lot of different auction designs for different situations. Therefore, when designing the renewable energy auctions, many factors have to be taken into account. More detailed design options for renewable energy auctions are presented in the next subchapter.

2.3 Auction design elements

As stated earlier, the detailed auction design can vary a lot. This is due to many design elements affecting the auctions. The design of these elements is very crucial for the auction outcome. If the design is not carefully considered, the auctions might work inefficiently, cause unwanted costs, increase instead of decreasing the support prices, decrease social acceptability of renewables and have other negative effects. When designed carefully, auctions can reach the target of adding the desired amount of renewable energy capacity with the lowest costs possible. *(del Río & Linares, 2014)* In this section, the main design elements are presented. Also their effects on the auction process are discussed.

2.3.1 Auction mechanism

There are several ways to decide the winner(s) of the auction, as presented in the previous subchapter Auction theory. Renewable energy auctions are in the most cases multi-unit homogeneous goods auctions, and thus those theories usually apply. The most used auction mechanisms for renewable energy are sealed-bid auction, with either pay-as-bid, uniform price or Vickrey auction pricing rule, and descending clock auction. *(Rego & Parente, 2013)* As stated before, renewable energy auctions are procurement auctions, and thus reverse to the auction theories presented above. Sealed-bid renewable energy auction functions basically exactly the way the regular sealed-bid multi-unit auction, but there is only one buyer (the auctioneer) and multiple sellers (the bidders). The bidders submit their bids with a price they want to receive from the auctioneer to realise their projects. As the auctioneer, naturally, wants to have minimum costs, the lowest bids are chosen and awarded to win. A descending clock auction as a procurement auction is actually a reverse version of a regular ascending clock auction: in the case of renewable energy auctions, the auctioneer announces a high support price to attract the interest of many bidders, and each round the price is reduced until the required quantity or in some cases budget is met. *(Fraunhofer ISI et al., 2014)*

Both auction mechanisms have their advantages and disadvantages. Sealed-bid auction has the advantage of being simple, thus lowering both the administrative costs related to auctioning and bidding costs for bidders, and according to some studies attracting more bids than open auction. When more bids compete in the auction, the hard competition incentivises the bidders to bid lower. Vice versa, a low level of competition is likely to increase the bid prices and thus cause problems with cost-efficiency, one of the main goals of the auctions. *(Rego & Parente, 2013)* On the other side, however, the static structure of the sealed-bid auction does not let the bidders to react to the behaviour of other bidders because the bids are submitted simultaneously. This can lead to a so-called winner's curse, where the winner feels it has valued the price too low. The descending clock auction addresses this problem by informing the bidders between the rounds about the outcomes, so that the bidders can adjust their offers in relation to the other bids, this way lowering the overall prices. *(Fraunhofer ISI et al., 2014)* However, descending clock auctions are more likely to encounter strategic or collusive bidding than sealed-bid auctions. By strategic or collusive bidding the bidders keep intentionally the bid prices higher than the real costs, thus increasing the final support costs. *(Rego & Parente, 2013)*

There are also hybrid models of the auction mechanisms. The most common of them is a model, where the first phase is a descending clock auction to allow price discovery for the bidders, and the second phase is a sealed-bid auction, where the bidders submit their final bids. In the final bids the bid price cannot be higher than the price determined in the last round of the descending clock phase. *(del Río & Linares, 2014)* This hybrid design addresses the disadvantages of the both sealed-bid and descending clock auctions by letting the bidders react to their competitors' bids in the first phase, thus lowering the winner's curse, and avoiding collusive or strategic behaviour in the second phase. It has also been stated that the hybrid model attracts more and also smaller bidders, increasing the competition, which is crucial for a cost-efficient auction outcome. *(Rego & Parente, 2013)*

2.3.2 Auctioned product

The auctioned product can be either capacity payments (€/MW/year) or payments related to produced energy (€/MWh). The capacity payments are actually similar to an investment grant, just divided over years. As capacity is the most used measure for power plant size, capacity payments have the advantage of being clear and simple for everyone. When the payments are in terms of capacity, however, it does not create any pressure for the power plant to actually be available and produce as much as possible. *(Klessmann et al., 2015b)* When the payments are in terms of produced energy, the plant is likely to use its maximum possible availability, and additionally it is easier to manage the power grid. As a disadvantage for payments for produced energy is the difficulty and thus extra risk for bidders to estimate as exactly as possible the average availability and stay on that plan during the years. *(del Río et al., 2015)*

2.3.3 Auctioned quantity

The capacity auctioned on a tendering round is usually in accordance with the longer-time goals for renewable energy capacity increase for the auctioning country. Ideally, the regulatory body plans the auctions and quantities auctioned each round so that in the end of a target period the long-time target is achieved, supposing that the auctions function as planned and the winner bid projects are realised. *(del Río et al., 2015)*

However, the experiences of already implemented renewable energy auctions show clearly that there are practically always winning bidders whose projects will not be realised. This is mainly due to strategic bidding, where the (often not serious) bidders submit too low bids in order to win the auction for example for strategic reasons. As the bid is too low, it is not feasible to actually realise the project with the awarded price, and the project is delayed or not realised at all. *(Fraunhofer ISI et al., 2014)* Other reasons for projects not being realised can be for example unforeseen problems during the constructing phase or too optimistic estimation of future cost decreases. There are design elements to address this problem, for example prequalification criteria for auction participants, financial guarantees and penalties for delay or non-compliance. *(Klessmann et al., 2015b)* These are all discussed more in detail in the related subchapters.

Because of a certain non-realisation rate of the projects in the auctions, the auctioneer has to take this into account when deciding how much quantity is auctioned. This excess quantity in contrast to the real, desired capacity increase has, however, some problems. The amount of necessary excess quantity is very hard to estimate, as the realisation rate depends on many design elements and other factors. To be able to estimate the excess quantity needed as accurately as possible, it would need many auctions to gather experience and iterate the right amount from those. Also a political problem of auctioned capacity differing from the targeted capacity expansion is faced: How to justify the seemingly difference between these amounts? *(Fraunhofer ISI et al., 2014)*

There is also a possibility not to auction quantity at all, but to decide a budget for the auction and to award winners until the budget is exhausted. This solution ensures for the regulatory body how high the overall support costs will be and therefore makes the budgeting simpler for the government. The support costs known beforehand simplify the allocation of the costs for example to the electricity consumers or other necessary stakeholders as well. *(del Río & Linares, 2014; del Río et al., 2015)*

2.3.4 Auction frequency

Auctions should be organszed on a regularly basis, according to the country's plan of renewable energy implementation targets (*Klessmann et al., 2015a)*. Some early experiences show that unpredictable timetable of the auctions is likely to cause stop-and-go behaviour for the (domestic) manufacturers and decrease the incentives for development of renewable energy technologies. *(Agnolucci, 2007)* The reason for this is the uncertainness, as the actors cannot know when the regulatory body will have the auction next time and if it is profitable to continue manufacturing and developing as the they cannot be sure when their products will next time be needed. *(Klessmann et al., 2015a)*

When it assured that the tendering rounds are organised regularly and that the possible bidders are aware of the regularity and can trust on it, remains the question of how often it is feasible to call for tenders. The specific technology affects, naturally, the decision of how often the auctions are held: the average project realisation times are different for different technologies, for example for wind and solar power. Generally, if the rounds are held often, it is more convenient for the bidders: if they fail in one auction, they will have the chance to win on the next round inside a small time frame. Often held auctions also avoid the stop-and-go problem, as there are almost continuously new projects needing the equipment from the manufacturers. When the auction take place often, it is also easier and quicker to learn from auction outcomes and possible to do corrections to the procedure. However, often held auctions increase the administrative costs and decrease the participant number in each round, lowering the competition level. *(del Río & Linares, 2014; Klessmann et al., 2015a)*

Decreasing the auction round number per time unit allows more participants per round, thus increasing the for auctions essential competition. This way the possible collusive or strategic behaviour is also decreased. As there are fewer rounds per time unit, the administrative costs become automatically lower. On the other side, seldom held auctions can cause stop-and-go behaviour among the manufacturers. This is especially critical for the domestic actors in renewable energy business. As both the often and seldom held tendering rounds have their advantages and disadvantages, it important to find a suitable regularity that minimises the problems related to this issue. *(del Río et al., 2015; Klessmann et al., 2015b)*

2.3.5 Contract duration

It is widely agreed that the contract duration and thus the remuneration period for the winner bids should be relatively long. Depending on the technology, it could be for example 10 to 20 years. Securing long support period for the winner projects gives an easier access to the finances for the bidders. This normally reduces the bid prices, thus resulting in a more cost-efficient auction outcome. *(del Río & Linares, 2014)* However, significantly too long support periods might lead to high costs to the society, as the support has to be paid over a long time. Thus, technology-specific, relatively but reasonably long support periods should be considered. *(del Río et al., 2015)*

2.3.6 Prequalification criteria

As already described in the section 2.2.3 Auctioned quantity, there is always a certain non-realisation rate among the winner projects. As it is beneficial to get as high realisation rates as possible to increase the amount of renewable power efficiently, instruments to address the non-realisation problems are required. Prequalification criteria for the bidders is one relatively efficient way of ensuring the seriousness of the bidders. Typically, prequalification criteria demand the bidders to have certain, first-phase steps of a project to be already realised when submitting the bid. For example, site permits, grid access, proofs of healthy economic state of the actor or financial deposits can be included in the prequalification criteria. Only the bids fulfilling the criteria will be evaluated and thus able to win the auction. *(Fraunhofer ISI et al., 2014; Klessmann et al., 2015b)* Prequalification criteria also at least partly defines at which state of the project the bidders can attend the auctions. If many and strict prequalification criteria are required, the project is already in a more developed state when entering the auction than if only few or no prequalification criteria are required. *(Klessmann et al., 2015a)*

When prequalification criteria are required from the bidders, the bidders must already prior to the actual auction have carried out some crucial project steps. As the steps in the most cases require financial investments or at least work load from the bidder, the criteria prevent unserious, strategic bidders with intentionally low bids and no realization intentions, because the costs used for fulfilling prequalification criteria are on the time of the auction already sunk costs and cannot be received back. *(del Río et al., 2015)* In addition, as the bidder already gains some more information and knowledge about the project by carrying out the pre-phases, the bidder has a greater possibility to know the real project costs and bid according to these. The project is also possible to be realised in a shorter time after the auction than in an auction design without any pre-phases required to be carried out before bidding. However, strict prequalification criteria tend to attract less bidders, because, as mentioned, the costs prior to the auction are already sunk costs after the auction and in case of losing the auction the bidder will not get the money back. This risk has to be known by the regulatory body when defining the prequalification criteria to assure sufficient competition. Confirming the prequalification criteria of the bidders also causes additional administrative costs to the regulatory body. *(Fraunhofer ISI et al., 2014; Klessmann et al., 2015b)*

2.3.7 Minimum number of bidders or bidder concentration

In the most cases it is necessary to have some rules considering the bidder number or concentration when awarding the winning bids. If no rules are applied, one single bidder or only a few large actors might be awarded the contract with a relatively high price. A minimum number of bidders explicitly expresses the minimum number of different actors whose projects will be awarded, even though the bid(s) from only one actor would be at the lowest cost and sufficient to fulfil the tendered quantity. Bidder concentration limits define for example a maximum percentage that one actor can be awarded from the auctioned quantity. If the auction attracts so few bidders that the minimum number or concentration rules are not satisfied, the regulatory body may cancel the auction *(del Río & Linares, 2014)*.

2.3.8 Price limits

It is possible to set a maximum or minimum price for the auction. That defines the restrictions of how high or low bids are qualified to be awarded. Setting a minimum price is a way of preventing underbidding and ensuring that the projects awarded are likely to be realised. Setting a maximum price allows the regulatory body to cap the auction costs to a certain amount and to prevent collusive behaviour of the bidders by not letting them bid strategically too high together. *(del Río et al., 2015)* Setting a maximum and/or minimum price for the bids, however, causes additional work for the regulatory body and forces it, against the initial auction logic of market knowing and deciding the actual price better, to consider the price of support needed and thus appropriate minimum or maximum limits. If the limits are chosen wrong, the auction outcome will not be the most cost-efficient one: when maximum price is known beforehand, the bidders tend to bid marginally close to that price, even if that would not be the real price. If the maximum price would not be announced to the bidders, it would decrease the transparency of the auction and increase the bidder risk. If the minimum price is set too high, the auction would not be an efficient instrument of discovering the real, most cost-efficient prices for renewables. *(Klessmann et al., 2015a & b)* A too high minimum price can also lead to regulatory body neglecting the price limit, if most of the bids fall under it, thus losing the whole target of setting a minimum price *(Kylili & Fokaides, 2015)*.

2.3.9 Banding

Auctions can be organised for all the renewable technologies as one auction, where the different renewable technologies compete against each other, or by applying technology bands, i.e. having separate auctions for different technologies. One option is also to have the technologies in the same auction but reserving a certain percentage of the awarded bids for each technology. *(Klessmann et al., 2015a; del Río & Linares, 2014)* When banding is applied, it is more likely that the real costs of each technology are revealed. All the renewable technologies have for example different cost structure, market situation and project length. If all the technologies are considered in one auction (also without percentages for each technology), it is likely that the cheapest of the renewable energy technologies win the most quotas awarded, the more expensive technologies do not have the chances to win and thus not all the renewable potential of a country is used. *(del Rio et al., 2015)* Also in technology-neutral auctions mature technologies usually overrun the immature technologies, and this way decrease the incentives to develop further the not yet mature but promising technologies. On the other hand, when banding different technologies to separate auctions or allocating a certain percentage to each technology, the competition level decreases as all the actors are divided into several tendering processes. Thus, when deciding the banding of the tenders, the regulatory body should be aware of the market situation in each technology field and assure the competition in each band to ensure an efficient auction outcome. *(del Río & Linares, 2014)* Using banding, however, seems an attractive option, as the optimal design of the different design elements differs from technology to technology, and by banding it is possible to use the optimal design for each technology and not to try to make a compromise satisfying all technologies to some degree *(Klessmann et al., 2015a)*.

2.3.10 Geographical restrictions

If the geographical locations of the bidders' projects are not regulated or controlled, it logically leads to a lot of installed capacity in locations with the highest yields, for example for wind energy the windiest places. If all the renewable power production is concentrated in only few areas, problems with local acceptance, power grid limitations and producer surpluses may appear. If a lot of renewable power plants are built in the same region in a short time frame, local people easily start to object it because of the "not in my backyard"-effect. When the renewable power is more distributed, the effect on each region is smaller and it is less likely to encounter negative attitudes towards renewables. Electricity grid capacity is also one important aspect when considering adding renewable energy: when building only in one region, the grid capacity limits will most likely be encountered and there will be grid congestions, not allowing the produced energy to be distributed to consumers efficiently. Producer surplus becomes a problem when there are projects awarded also in sites with not so high yields. In this situation, projects with profitable and not-so-profitable sites might get the same support, which is set by the worse site, and thus the better site project is paid too much support, lowering the cost-efficiency of the auction. *(Fraunhofer ISI et al., 2014)*

The problems related to free site selection of the bidders can be addressed by pre-selected sites by the regulatory body (acceptance and grid problems) or different support rates for sites with different yields (surplus problem) *(Fraunhofer ISI et al., 2014)*. If the sites are pre-selected or even different auctions held for different sites, it causes less competition and therefore might lead to less cost-efficient outcome. However, site specifications to some degree seem to be necessary. If sites are pre-selected, the transmission companies are easy to include with the site decision process, thus ensuring the grid capacity with the new renewable capacity, and sites are in that case also pre-approved by a permitting authority. This reduces the pre-auction costs for bidders, lowers the bidder risk and improves the possibility of also for example small actors to take part to the auctions. It also increases the realisation rate of the project, as one major initial project step is already taken. *(del Río & Linares, 2014)*

2.3.11 Evaluation criteria

The winners can be decided either only by the lowest price rule or with a multi-criteria evaluation. The multi-criteria evaluation might take into account also for example environmental, grid, actor variety, local acceptance and geographical issues and not only organise the bids in the order of the lowest price. If the only evaluation criterion is price, the other important aspects, such as environment and grid, can be included to pre-qualification criteria, which again causes an additional risk to the bidders by increasing the pre-auction costs. Price-based evaluation is, however, much more simple and transparent than multi-criteria evaluation, as the rules are easily comprehended and there are no issues of for example trying to objectively evaluate rather abstract criteria like local acceptance. It is also more likely to achieve the most cost-efficient outcome with a price-based than multi-criteria evaluation. The other important issues, however, cannot be evaluated with the price-based evaluation but can only have for example maximum or minimum limits set by prequalification criteria, and thus the bidders will not have the incentive to reach for the optimal solution in regard of the other, for example environmental, issues. *(del Río et al., 2015; Klessmann et al., 2015a & b)*

2.3.12 Deadlines

In the most cases, it is beneficial to have a deadline after the auction is held to define the time in which the awarded projects have to be realised. A deadline makes sure that the projects are realised in a reasonable time frame and the increase in renewable power is implemented as planned. *(del Río & Linares, 2014)* If no deadline is set, it may attribute to a higher non-realisation rate as the bidders might wait too long time for lower prices due to expected price development *(Agnolucci, 2007)*. When the deadline is set, it has to be considered carefully, how long period of project compliance is suitable for each type of renewable energy. If the period is short, it sets pressure to the bidders prior to the auction and thus increases the bidder risk. If the period is too long, it might let the bidders think too optimistically about future price reductions and thus bid too low. Therefore, it is important to set the deadline technology-specifically, as the different technologies have very varying average implementation times. *(del Río et al., 2015)*

2.3.13 Penalties for non-compliance or delay

As mentioned, auctions might have a problem of projects not being completed, when the auction design is not carefully considered. One efficient method to increase the realisation rate, in addition to deadlines and prequalification criteria, is setting penalties for non-compliance or delay. When the bidders know prior to bidding that a penalty will be applied if the project is not realised, it sets an incentive for them not to bid strategically too low without a real intention to realise the project. *(Klessmann et al., 2015b)* The penalty can be either a payment which the bidder has to pay in case of delay or non-compliance or lowering (gradually) the contracted support in case of delay *(del Rio & Linares, 2014)*. When applying the penalty payment, the bidders must normally submit a deposit or guarantee in order to ensure the paying of the penalty if the project is for example not completed because of economic problems of the bidder. As penalties are implemented as a part of the auction process, it should be taken into account that it is an additional economic risk for the bidders, and the risk will most likely be added to the bid price. Therefore, the amount of the penalty has to be considered carefully to still be a relatively small risk to the bidders but large enough an incentive to force the winning bids to be realised. *(Fraunhofer ISI et al., 2014)* A high penalty might also deter participation and especially reduce the attractiveness of the tendering process for small actors *(del Río & Linares, 2014)*.

The reason for non-compliance or delay of a project can be caused either by the bidder or by some external, not bidder-related factor. When all cases of non-compliance or delay are penalised, even if the reason is not caused by the bidder, the bidders might face a too high risk. Therefore, it can be reasonable to apply the penalties only in case of delay or non-compliance is caused by the bidder. However, it is often not simple to distinguish clearly if a failure is caused by the bidder or some external reason. This might lead to unclear rules of the contract and therefore additional problems when deciding if the bidder should pay the penalty. Thus, some larger external risks could be included for example in the prequalification criteria or pre-selection of the project sites and then implement an unconditional, simpler penalty. *(del Río & Linares, 2014; Klessmann et al., 2015a)*

2.3.14 Secondary market for successful bids

One way to decrease the bidder risk caused by penalties is to create a secondary market for winning projects. In this market, the winning bidders could have the possibility to give the project to another market actor and at the same time pass the support contracted and the obligation to build the project. Ideally, the secondary market would consist of all the market actors and thus lower the penalty risk of a single bidder. However, a secondary market increases the administrative work and costs and the complexity of the auctions. *(Fraunhofer ISI et al., 2014)* The cost-efficiency might also decrease, as some actors might not bid themselves but wait for the secondary market, thus reducing competition. One way of avoiding the complexity caused by secondary market but still decreasing the bidders' penalty risk is to allow the winner bidders to change the project to be realised while keeping the same awarded support and obligations to realise the project. This reduces, however, the competitiveness of small actors as they do not have the same possibilities of a large production portfolio and thus changing the project as easily. *(Klessmann et al., 2015b)*

3 Small actors in renewable energy auctions

3.1 Definition of a small actor

Some of the biggest questions to be solved with the right design of renewable energy auction of their early implementations were to ensure enough competition to enable a functioning, non-collusive auction and to achieve high realisation rates *(Agnolucci, 2007; Rego & Parente, 2013; del Río & Linares, 2014)*. However, another important question has risen and drawn attention all the time more in the recent past years: actor diversity in the renewable energy auctions. By actor diversity, participation of different-sized actors from different origins is meant. In a naturally competitive market all the market players from large, international companies to medium-sized domestic firms and small family businesses should have a chance to enter the market and practice the business fairly. The same applies for energy production markets. However, when a support instrument is implemented to promote some means of energy production, the completely free competitive market is violated. Therefore, it is important to take the actor diversity into account when implementing support methods. *(Klessmann et al., 2015a)* As this thesis discusses the role of small actors in renewable energy auctions, it is important to define a small actor. The definition, however, is not a simple task. If some special rules or advantages are applied only for small actors in the auctions, the definition must be unambiguous and in a legal context only one way interpretable. There are some varying ways for defining a small actor, and those ways are presented in this chapter. *(Tiedemann et al., 2015)*

EU has a definition for small and medium-sized actors. This definition can be used also for renewable energy auctions. It defines the amount of employees and either the annual turnover or annual balance sheet total. According to this definition, micro-sized enterprises have less than 10 employees and a turnover or balance sheet total of maximum 2 million euros. Small-sized enterprises have less than 50 employees and a turnover or balance sheet total of maximum 10 million euros. Middle-sized enterprises have less than 250 employees and a turnover of maximum 50 million euros or a balance sheet total of maximum 43 million euros. *(European Commission, 2003)* If all the three classes of this definition should be considered as small actors in renewable energy auctions or only micro and/or small-sized enterprises, depends on the market situation in a certain country and technology field. Even though this EU definition is exact and rather simple to prove, some problems might still arise when applying this rule to renewable energy auctions. As one typical kind of small actors are citizen projects, which haven't had any projects or business earlier, the turnover and/or balance sheet total cannot be verified for these actors. A further problem might arise if the project is for strategic reasons initiated by a small enterprise but after winning the bid transferred to another, larger company, if the auction design allows this. *(Tiedemann et al., 2015)*

Another possibility is to choose to define only from local citizens initiated cooperatives or companies as small actors. A report specialized in energy projects from local cooperatives defines these projects to be from local people and/or business or agricultural enterprises, excluding large companies, and these actors alone or together initiate a project so that at least 50% of the votes stay within actors who live or come from the region where the project is going to take place. *(Hauser et al., 2015)* This definition of small actors emphasises the locality of the actors and thus reinforces local acceptability of the renewable energy projects. However, the definition is easily misinterpreted and cannot be defined exactly enough for a legal context. This is likely to lead to problems with misuse of the status of a small actor. *(Klessmann et al., 2015a)*

One possibility is also instead of defining the size of the actor to define the size of the project. When this definition is applied, it is assumed that small actors plan small projects. This definition is called De-minimis rule. When a maximum project size for a specific technology is defined, the rule is easy to understand by the bidders and to prove by the auctioneer. *(Klessmann et al., 2015b)* It is, however, clear that not only small actors can create small project, and if small projects would achieve advantages when applying this rule, it would be attracting also for large actors to plan small projects and the rule would lose its significance. It could also lead to less efficient auction income if the bidders would intentionally divide their projects into many smaller projects to achieve the advantages of De-minimis rule and thus lose the cost-efficiency of economies of scale. *(Klessmann et al., 2015a)*

It can also be assumed that small actors have a lower participation frequency in the auctions than the larger ones. Therefore, the participation frequency can also be used as a definition for small actors. It should be, however, only used with the EU definition of a small actor (or similar criteria defining the size of the actor), otherwise the large actors have an incentive to take part to the auctions less frequently. It should also be considered, if the bidders exceeding the frequency limit should be excluded of the definition with all their projects or only with those projects exceeding the limit. A special case of participation frequency limit is to allow small actors once have advantages of the definition and from the next project of the same actor the normal auction rules would be applied. This would especially address projects of local cooperatives, who tend to create only one project for their own region, but on the other hand, set small project developer companies, who as well have difficulties to compete against large international ones, in a disadvantaged position. *(Klessmann et al., 2015a)*

As can be seen, the definition of a small actor can be problematic and also dependant on the country and technology context. In this chapter in the following subchapters, the suitability of renewable energy auctions for the small actors, importance of small actors in the markets and possible optional ways for small actors when not being able to compete in auctions are not discussed under any specific definition of the presented ones, but rather under a general assumption of small actor meaning for example small companies, local cooperatives and private citizens, without defining more exactly the small actors.

3.2 Suitability of renewable energy auctions for small actors

As stated in the previous subchapter, actor diversity and the chance for every kind of actors to fairly practice their business in the energy markets has been drawing more attention lately. It has been noticed, however, that renewable energy auctions attract significantly more large actors than small actors, such as local cooperatives, small project developers or private citizens. This outcome is no surprise, if a typical renewable energy auction design is taken a look at more closely. Many elements can be found, which set the small actors in a weaker position compared to larger actors. *(del Río & Linares, 2014; Sawin, 2004)* Even EU has defined in its State Aid Guidelines that when implementing renewable energy auctions, exceptions are allowed with small actors. This indicates, too, that small actors might encounter some problems in these auctions. *(European Commission, 2014b)*

Small actors typically develop smaller and fewer projects than large actors. This fact leads to the lower chances to bid successfully in renewable energy auctions. The small projects do not have, naturally, the benefits of economies-of-scale, so that the investment and production costs per unit would be low. Therefore, small actors have to set higher bids to be able to cover the costs of their projects. As auctions are competitive and the aim is to achieve the lowest possible costs, the bids with higher costs will be neglected and thus the bids of small actors often fall into the neglected class. *(Klessmann et al., 2015a)* The small size of both the actor and the project also causes the actual bidding costs to be higher per unit. The bidding costs arise mostly from the bidder familiarising with the auction mechanism. These costs increase the bid even more, and auctioning itself might scare some small actors as they are generally not that familiar and used to auction systems as the larger companies. *(Tiedemann et al., 2015)* The peculiarity of the auction system to many small actors may also cause problems with bidding strategies: if the actor is not familiar with the auction mechanism and thus with suitable and successful bidding strategies, it has to create those. For successful strategies, expert consultation is often useful or even crucial, thus causing again extra costs to the bidder, which in case of a small actor divide to smaller quantity and once more the costs per unit and the bid price increase. As small bidders might want to lower the bid by not investing that much on the bidding strategy development, larger actors have the advantage of, additionally to often lower bids, bidding more strategically and also therefore being more likely winners. *(Klessmann et al., 2015a)*

In addition to higher bids, also the fact that participating to the auctions is harder for small than large actors, lowers the auction attractiveness and the chances of successful bidding for small actors. In the most cases, bidders will need some external financing for their projects. The small actors normally need proportionally more financing than the larger ones, who already may have collected profits from multiple previous project. *(Klessmann at al., 2015a)* Furthermore, as small actors do not always have as stable financial state as the larger ones, the access to the finances is often harder and the financing conditions worse *(del Río & Linares, 2014)*. The harder access to finances does not only affect the project financing of small actors but also the ability to pay possible deposits, for example as a guarantee of penalty, required to the auctioneer *(Fraunhofer ISI et al., 2014)*. The penalties as such, as well, place another difficulty: in case of non-realisation and the obligation to pay the penalties, small actors might be in bankruptcy more likely than the larger bidders, who have more liquidity gained from many other projects *(Klessmann at al., 2015a)*. If high prequalification criteria are required or by other design elements (e.g. deadlines) it is implicitly expressed that the project has to be in a mature phase when entering the auction, small actors might not be able or willing to fulfil all the criteria *(Fraunhofer ISI et al., 2014)*. The project development costs prior to the auction are already sunk costs at the time of the auction and the small actors are more likely to be neglected than the larger ones, because of the often higher bids, so it is likely that small actors have invested proportionally high amounts in a project that cannot be realised *(BMWi, 2015)*. One more risk is set if the auction design allows the winning project to be changed after the auction – large bidders can count on their large production portfolio and bid therefore lower, but small bidders seldom have such portfolios and do not really have the possibility to change the project in case of unpredictable negative incidents. All the reasons presented in this paragraph decrease the attractiveness of auctions for small actors and lowers their willingness to even start to bid. *(Klessmann et al., 2015a)*

Even though the list of negative features of the auctions from the point of view of a small actor is long and the obstacles might seem high, it is not necessarily obvious that small actors cannot participate successfully to the renewable energy auctions. Small actors have also some advantages compared to larger actors. They normally do not have as high profit expectations from the projects as large, international companies, and thus they can use this as a lowering factor in the bid prices. Moreover, small actors often also develop projects for their own geographical region, where they might be already known and accepted by the local citizens. This sets them in a significantly more favourable position as the larger companies among the local people, and is also one of the main arguments in the next subchapter, which discusses the importance of actor diversity. *(del Río, 2015; Klessmann et al., 2015a)*

3.3 Discussion of the importance of actor diversity in renewable energy auctions

As small actors might encounter many problems in renewable energy auctions, it is a relevant question to discuss if they should be excluded from the auctions or if it is important to design the auctions so that also small actors can fairly attend them. In the past years, one of the factors enabling such a rapid renewable energy implementation is the participation of different types and sizes of actors. Different kind of actors tend to build different kind of renewable projects, thus exploiting the whole renewable potential of a country. If only one or very few kind of actors would be active market players in the renewable field, it is likely that only some of the potential would be used. *(Fraunhofer ISI et al., 2014)*

However, as can be concluded from the previous subchapter, the bids of small actors are often higher than the bids of larger companies. If some small actors are awarded as winners in the auctions even if their bids are not the lowest ones among all the bids, by designing the auctions favourable for small actors for example with multiple evaluation criteria, the basic principle of the auctions of choosing the most cost-efficient options is violated. By preferring smaller actors or for example reserving a certain percentage of the volume auctioned for small actors even if the bids were higher than some other bids would cause additional costs to the society as the remuneration amount is higher and not the optimal outcome which would occur in a pure competitive auction. *(Klessmann et al., 2015b)* Thus, one of the main questions when deciding if small actors should be taken into account is if actor diversity should be preferred over the cost-efficiency of the auctions and optimally minimized support costs *(Fraunhofer ISI et al., 2014)*.

One of the most important arguments stating that small actors should not be excluded from the renewable energy auctions is the social acceptance of the auctions and renewable energy in general. As the auctions tend to favour the least-cost projects, the bidders allowed to actually implement their projects have most likely chosen large-scale projects often with large installations. Moreover, to achieve the least costs, the project sites are often chosen carefully to be in a geographically optimal location, for example for wind turbines in the windiest regions or for solar panels in the sunniest areas. The local people close to the good renewable regions will experience a huge building boom, and this easily leads to the "not in my backyard"-effect. If the local people start to oppose the new renewable projects in their regions, the negative attitudes easily spread wider and might over the time lead to negative attitudes towards the renewable energy auctions. In case this happens, it is very challenging for the policy-makers to try to continue a system that is not accepted among the citizens. *(Fraunhofer ISI et al., 2014; Klessmann et al., 2015a; del Río & Linares, 2014)*

Small actors, however, are often exactly those local people, their cooperatives or some family businesses, which already are in favour in the region and socially accepted. The projects are also often smaller and thus do not for example cause as large landscape problems. Furthermore, assuming small actors to be local people, the projects are often built in their own regions and not necessarily finding the optimal location nationwide. Thus, the projects of small actors are in many cases more equally spread over the country and do not cause as high an exploitation of only few areas. *(Fraunhofer ISI et al., 2014)* The equally-spread power production also mitigates power grid congestion problems: when large amounts of electricity are produced in only a few geographical locations, it becomes a challenge for the power grid to transport the electricity through the few transmission lines near to the large power production sites, and grid congestions may occur, not allowing all the produced power to be utilized. If the power production is more wide-spread, the transmission lines do not experience as high requirements for transmission capacity. *(del Río, 2015)*

There is also a possibility to allow small actors to receive remuneration by some other means even though the general principle of support allocation would be the auctions. As small actors would not in this case be excluded from the renewable energy markets, the most of the above mentioned advantages of having small actors in the markets would hold. The different renewable potential possibilities of a country would still be exploited. Local, small actors would still have the chance to implement their projects and thus mitigate the local acceptance problems. However, as high an amount of large projects of large actors in the most profitable sites would be likely to occur as in case of no small actors in the markets at all. Thus, including small actors to the auctions would probably cause higher local acceptance than allowing them another support method as an exception. *(Klessmann et al., 2015a)* Small actors also increase the competition level of the auctions. The more actors are allowed or attracted to take part to the auctions, the harder the competition is and the smaller is the possibility of collusive behaviour of the bidders. Thus, including small actors in the auctions could also help to mitigate one of the main problems of the auctions, a too low competition level. *(del Río, 2015)*

All in all, it seems that small actor participation in some form is important for the renewable energy markets. Now without preferring one or the other option, either the renewable energy auctions should be designed so that also small actors can take part to them, or small actors could be excluded from the auctions but taken into account in some other form of remuneration. A short overview of the other possibilities than auctions for small actors is presented in the next subchapter to provide a better understanding on the topic, however not going into details, as it does not belong to the scope of this thesis.

3.4 Other possibilities not to exclude small actors from renewable energy markets

In the previous subchapter it has been stated that small actors should not be excluded entirely from the renewable energy markets. However, as the auctions might in some cases not be suitable for small actors, other means of support can be considered to allow small actors to stay on the market. Without any support method small actors could not create economically feasible projects and would thus fall off from the markets. *(Klessmann et al., 2015b)* As the main focus of this thesis is on the renewable energy auctions, only a short overview of other options is presented.

One option of small actor remuneration is a normal feed-in tariff. The regulatory body would decide an amount of support small actors could receive for their renewable projects, and any small actor (according to a pre-defined definition) with a renewable project would be eligible to receive it. *(Klessmann et al., 2015a)* This would be a simple method to ensure small actors in the markets, when the remuneration level is chosen high enough. However, a regulatory set support level would contradict one of the main goals and reasons of auctions, the cost-efficient remuneration of renewables. An alternative to a regulatory set feed-in tariff would be to allow an access for small actors to the same support level as which was defined for the winning projects in the auction. *(Klessmann et al., 2015b)* The price could also be defined in this case as an average price of a few of the past auction rounds *(Tiedemann et al., 2015)*. This leads, however, to the question if this amount is enough for small actors, as one of the main reasons for excluding small actors from the auctions is that they usually have higher costs than large bidders and thus would need more remuneration. To define a remuneration level that is both cost-efficient and still high enough for the small actors, separate auctions for small actors could be organised. A major problem with only few participants and thus too little competition would, however, be likely to occur. *(Klessmann et al., 2015b)*

As can be seen, there are some ways to enable small actor participation in renewable energy markets even when the auctions are implemented. The auction design itself has also a large significance when considering the small actor friendliness of the auctions. In the next chapter, experiences from countries, which have already implemented renewable energy auctions, will be presented. The experiences will be discussed especially from the point of view of small actors.

4 Practical experiences

4.1 Germany

The two politically most significant guidelines leading the German energy policy are its Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz, EEG) and the Energy Transition (Energiewende). The EEG was first set on April 1st 2000, and last time renewed on August 1st 2014. In EEG it is defined that Germany will have 40 to 45 percent of its electricity demand from renewables until 2025 and 55 to 60 percent until 2035. The longer timeframe goal is to have at least 80 percent of the electricity demand from renewables in 2050. *(EEG, 2014)* In the first half of 2015 the corresponding percentage was 32,5% *(BMWi website, 03.12.2015)*. To reach the goals, EEG *(2014)* sets that at the latest in 2017 the remuneration for renewable energy production will be defined in competitive auctions.

Germany is one of the countries where renewable energy implementation has experienced a significant and rapid increase in the last years. This is due to a generous feed-in tariff that Germany has been offering for renewable energy projects. At the moment Germany is among the leading countries in the world in solar and wind energy production percentages of the total energy production of the country. The feed-in tariff has been efficient in increasing the renewable energy share of energy production. However, the costs for the renewable support by feed-in tariff have been high. Furthermore, feed-in tariff has allowed renewable energy to be built practically anywhere and in not exactly planned amounts, thus missing proper and coordinated planning of implementation. Therefore, it was reasonable to re-think the remuneration method in Germany, and along the EEG update in 2014, it was decided to move to auction-based support for renewables. Auctions are supposed to decrease the costs of renewable energy support and also make it possible to control the quantity of new renewable implementations. *(BMWi, 2014a)*

The renewable technologies contributing to the most of the renewable energy increase in Germany are wind and solar energy. Additionally, Germany has also a relatively significant amount of hydropower and biomass-based energy production and some geothermal energy, but their contribution to the German Energy Transition is not as large: the amount of hydropower and geothermal power has stayed relatively same during the last years, and whereas biomass has experienced rather high yearly increases some years ago, in the few last years the increase has slowed down. Germany considers wind and solar power more cost-efficient options for Energy Transition, and thus, the German renewable energy legislation and remuneration concentrates more on those two technologies than on hydropower, geothermal and biomass. *(BMWi, 2014b)* Therefore, renewable energy increase targets are set technology-specific as following: for solar and onshore wind each 2,5 GW new installations yearly, for offshore wind a target of 6,5 GW total installed capacity until 2020 and 15 GW until 2030, and for biomass 100 MW new installations yearly. For offshore wind, the cap is fixed. For the other mentioned technologies, the cap is flexible: if more than the targeted amount is built, the support will be lower for the quantities over the cap. *(EEG, 2014)*

The German energy sector, especially the wind and solar sectors, are at the moment characterized by a large actor diversity. Large as well as small actors have been under feed-in tariff system building up renewable energy plants, and one reason for the high new renewable deployment is this actor variety: with many different actors who tend to implement different kind of projects, all the renewable potential of a country is utilised. *(Klessmann et al., 2015a)* Germany has realised the importance of the actor diversity in its renewable energy field and that small actors have often difficulties to be successful in auctions. Therefore, in the same article in the renewed EEG *(2014)* where the auctions are defined to be the renewable support method at the latest from 2017 on, it is also defined that the actor diversity is to be kept as high as it is at the moment in Germany. This shows clearly that it is important for Germany not to forget small actors or on purpose let them fall off the energy production markets.

To experiment the auctions as a remuneration method, Germany organised 15th of April 2015 the first pilot auction for ground-mounted solar photovoltaic (PV) installations. After the first solar PV auction, two subsequent auction rounds for ground-mounted PV plants were held in 2015, 1st of August and 1st of December. The six next auction rounds are already decided: for both the years 2016 and 2017 three rounds. *(FFAV, 2015)* The ground-mounted solar PV installations were chosen to be the pilot auction technology in Germany, because PV installations are relatively fast to implement, and thus the experiences of the auctions are possible to collect in a short time frame. From 2017 onwards, the support for all the different renewable energy technologies is to be defined by the auctions. *(Bundesregierung, 2015)*

The most important design aspects of the German PV auctions are described here. The auctioneer of the German PV auctions is the Bundesnetzagentur. The auctioned volume in the first two rounds was 150 MW and in the third round 200 MW. The planned volumes for the coming auction rounds are 125 MW for the two next rounds, 150 MW for the third coming round and 100 MW for the last three planned rounds. Altogether the auctioned volume over the three years is 1200 MW. If the volume of the previous round is not fulfilled, it will be added to the next round's volume. The auction is organised as a sealed-bid, pay-as-bid auction, where the only evaluation criterion is the price of the bid, and if the price of several bids is the same, the bids with smaller capacities are preferred. The second and third auction rounds are exception, they are organised as uniform-price auctions to gather experiences. *(FFAV, 2015)*

Every bidder must submit the bid price, i.e. remuneration level, in terms of produced electricity (c/kWh) and the volume of a bid is to be announced in PV plant capacity (kW). The volume of a bid must be at least 100 kW and at most 10 MW, and one bidder is allowed to submit several bids. The first round of the PV auctions had a ceiling price of 11,49 c/kWh, which decreased for the next two rounds held. As prequalification criteria the bidder must provide the exact location of the planned installation, and additionally either a decision on the building plan, a decision on the publication or an approved building plan on the location for the installation. A financial guarantee of 4 euros per kilowatt-hour of the bid volume must be deposited by the bidder if a decision on the building plan is included in the bid, and if a decision on the publication or an approved building plan is attached to the bid, only 2 euros per kilowatt-hour is required as a deposit. *(FFAV, 2015)*

After the auction, the successful bidders must submit a second financial guarantee in ten working days from the auction results publication. The second guarantee amounts to 50 euros per kilowatt-hour or 25 euros per kilowatt-hour, respectively, with the conditions that applied also to the first deposit. If more than 30 MW of projects fail to deliver the second financial guarantee, an extra auction is held for the capacity failed. In this auction all the bids, which fulfilled the prequalification criteria in the first round but were not successful, are able to participate. The project must be built and commissioned within 18 months, otherwise the remuneration decreases by 0,3 c/kWh. The remuneration is also decreased by 0,3 c/kWh if the project location is changed (which, however, is in principle possible). If the project is not realised within 2 years, it is considered as failed and the remuneration for that project is cancelled. It is not allowed to change owners of the awarded project before the commission of the PV installation. After the commission, the project owner is allowed to sell the project to a third party. The financial support is guaranteed for the first 20 years from the commission of the plant. If the bidder cancels the project after winning the auction, a penalty of the amount of the first financial guarantee is to be paid. If the bidder fails to deliver the project within 2 years, a penalty of the amount of the second financial guarantee is to be paid. *(FFAV, 2015)*

As it is important for Germany to preserve the high existing actor diversity, the auctions for solar PV are also designed to be suitable for small-sized actors. The design of the auctions is intended to be simple, transparent and understandable, so that also small actors have a possibility to participate. The flexible guarantee and penalty amount also reinforces small actors: if the bidder has a decision on the publication or an approved building plan, the guarantee and possible penalty is only the half of the actual amount. This way for example local cooperatives, which normally develop only one project, can avoid the high initial deposits and risks. Prequalification criteria for the bids is also kept low to attract small actors. Additionally, the decrease of the remuneration in case of changed location increases the actor diversity, as the large actors have to think carefully before using their advantage of a likely larger business area compared to for example local cooperatives. The awarding criteria is intentionally defined so that in case of same bid prices, the smaller capacities are preferred, thus increasing small actors' winning possibilities. *(Bundesregierung, 2015)*

As mentioned, the three first rounds of the German PV auctions are held. At the time of the writing of this thesis, there were results of the all three rounds available, and for the first round also a bidder feedback-based evaluation. In the first round, 170 bids with a total volume of 715 MW were received, of which 25 bids with a total volume of 157 MW were successful. The prices of the successful bids were between 8,48 and 9,43 c/kWh. Bids from many different kind of actors and of different sizes were received. *Table 1* presents the number of bids submitted classified in categories of actor types and the bid sizes. However, the most of the successful bidders were of one actor type, GmbH & Co. KG, which is a German form of business combining features of a limited liability company and a limited partnership. Additionally, the most of the bids were in the largest size categories. The actor categories of successful bids are represented in *table 2* and the size categories of them in *table 3*. *(Bundesnetzagentur, 2015a)*

Table 1 Actor types and project sizes of the submitted bids in the first German solar PV auction round (Bundesnetzagentur, 2015a, translated from German into English).

Actor type	0,1-0,5 MW	0,5-1 MW	1-2 MW	2-5 MW	5-10 MW	Total
Natural person	2	2	2	2	0	7
Civil law partnership	0	0	0	3	0	3
Limited liability company	3	4	8	20	16	51
GmbH & Co. KG*	4	6	15	33	35	93
Limited company	0	0	2	2	4	8
Registered cooperative	3	0	1	0	0	4
Other	0	1	2	1	0	4
Total	12	13	30	60	55	170

* GmbH & Co. KG is a German form of business, which is a combination of limited liability company and limited partnership.

Table 2 Actor types of the successful bids in the first German solar PV auction round (elaborated from BMWi website, 8.1.2016).

Actor type	Successful bids
Limited liability company	2
GmbH & Co. KG	21
Limited company	2
Total	25

Table 3 Project sizes of the successful bids in the first German solar PV auction round (Bundesnetzagentur, 2015a, translated from German into English).

Size of PV plant	0,1-0,5 MW	0,5-1 MW	1-2 MW	2-5 MW	5-10 MW	Total
Successful bids	0	1	2	7	15	25

The smallest successful project in the first round was a one-megawatt-project. Thus, small projects can be successful in the German PV auctions, even though the majority of the winners are bigger projects. However, no natural persons, cooperatives or civil law partnerships, which are the most typical small actors, were successful in the first round. Additionally, when subsidiary companies are taken into account, one company only was the winner of 40 % of the successful bids. The results report explains this to have been expected, with the market structure with large multi-project bidders. However, the report recognises also the actor types that were not successful and claims that the situation will be observed in the later rounds and when necessary, those actor types can be classified as small actors with special rules in order to preserve actor variety. *(Bundesnetzagentur, 2015a)*

The bidder feedback-based evaluation of the first round shows that in the opinion of the bidders the auction is not optimal for small bidders. Some of the feedback participants evaluated the participation of the auctions to cause much additional work load for example when familiarising with the auction method and compiling the bid. The majority were of the opinion that low experiences in project development or weak finances, which often feature small actors, lead easily to disadvantages in the auction participation. The feedback participants have also suggested some special categories or rules for small actors, a cap for winning projects of one actor or a simpler auction system to facilitate small actor participation. *(Bundesnetzagentur, 2015b)*

On the second PV auction round, 136 bids with a total volume of 558 MW were submitted and 33 of them with a total volume of 159,74 MW were successful. Many of the received bids were on the same pieces of land and from the same bidders as in the first round. Because of the uniform pricing of this round, the price for every successful bid was the highest successful price, 8,49 c/kWh. The lowest bid, however, was 1 c/kWh, which clearly indicates strategical bidding. The distribution of the actor types and project sizes of the submitted bids is quite similar to the first round: Bids were received from many kind of actors and in many project sizes. Moreover, the results of the second round are also very similar to the first round. The smallest successful project was again 1 MW and the most of the projects were in the two largest size categories, though more projects fell into the second-largest category as in the first round. The actor structure in the successful bids was somewhat different to the first one: there were no limited companies with a successful bid and one civil law partnership bidder was successful. However, the most of the successful bids were again from GmbH & Co. KG bidders and a few bids from limited liability companies. *(Bundesnetzagentur, 2015c)*

The third round received 127 bids with a total volume of 562 MW. From those, 43 bids were successful with a total volume of 204,165 MW. This round was also a uniform-price round, and the price was 8 c/kWh. Again, strategical bidding was to be seen in a small minority of the bids, as the lowest bid was 0,09 c/kWh. The bidder structure and bid project sizes were once again very similar to the two first rounds. This round, however, the smallest successful bid was only 499 kW and a larger variety of actors were successful: in addition to many successful bids of limited liability companies and GmbH & Co. KGs, there were three successful bids of civil law partnerships, three of natural persons and two of registered cooperatives. This shows a positive trend towards small actor successfulness in the three held auction rounds. It is stated, however, as also in the reports of the previous two rounds that the competition in these auctions is really high, and the prices of the bids have become every round lower. This normally decreases the chances of smaller actors to be successful. *(Bundesnetzagentur, 2016)*

It is still too early to draw conclusions of the successfulness of the German pilot PV auctions, as only three rounds are held and the successful bidders also from the first round have still some months time to commission their projects. However, as stated many times before, it is important for Germany to include also small actors in the renewable energy markets. The three rounds held show that it might be possible for small actors to be successful also in the auctions without any special rules, but the results and analyses of a longer time and especially from other renewable technologies are to be seen only after some years. To conclude the most relevant observations from the German renewable auctions from the point of view of small actors, a summary is presented in *table 4*.

Table 4 Summary of the German auction experiences from the point of view of small actors.

Technologies	solar PV
Small actors	small actors taken into account in design, actor diversity important
Experiences	small and large actors participating, mostly large actors winning, some small actors successful
Main problems in small actor participation	not (yet) enough successful small actors
Recommendations for small actors	simple auction design, smaller capacities preferred in case of same price, flexible prequalification criteria and penalty system, avoiding large actors using their wide portfolios (location and owner changes penalised or prohibited)

4.2 Denmark

Denmark is one of the world's leading countries in renewable energy implementation *(Kitzing & Wendring, 2015)*. The oil crisis in 1973 led Denmark to set ambitious goals for its own energy production, with both fossil fuels and all the time more with renewable energy sources. Since the end of 1970s, Denmark has been implementing wind turbines to produce electricity. Denmark was also the first country in the world to build offshore wind turbines in 1991. The real wind boom in Denmark started in the late 1990s. *(Danish Energy Agency, 2009)* As the situation of the year 2014, 38,8 % of the Danish electricity production was covered by wind energy, 11,4 % with biomass and 3,2 % with solar energy, hydro power and biogas, amounting altogether to 53,4 % renewable share in electricity production. The share of renewable energy in the total energy consumption was 28,5 %. *(Danish Energy Agency, 2015a)* Denmark has defined its renewable energy goals as following: in 2020 35 % renewables of total energy consumption and 50 % wind energy of electricity consumption, in 2035 100 % renewables of electricity and heat supply and in 2050 100 % renewables of total energy consumption *(Kitzing & Wendring, 2015)*.

In 2008, Denmark made a Promotion of Renewable Energy Act, which came into effect in the beginning of 2009. The Act sets the rules for putting up a wind turbine either onshore or offshore, or other kind of a renewable energy power plant. It also sets the support level as a feed-in tariff for onshore wind turbines and other renewable energy. According to the Act, the energy producers can receive support for offshore wind in two ways: either the same support that is offered for onshore wind, or after winning a public tendering procedure. The support is paid as a feed-in tariff. The dominance of wind power in the Danish energy market is clearly visible in the Act, as the most of the sections in it concern onshore or offshore wind turbines. *(Promotion of Renewable Energy Act, 2008)* Also before the Promotion of Renewable Energy Act, support was provided to renewable energy. In case of wind energy, it depended on the size and grid connecting date of the wind turbines. With the Act from 2008, the Danish government wanted to improve the attractiveness of putting up wind turbines to achieve the renewable goals, and therefore increased the previous remuneration level. *(Danish Energy Agency, 2009)* At the moment, Danish parliament is strongly supportive towards renewable energy and especially wind energy, thus the wind-friendly policy security for the near future is relatively high *(Danish Energy Agency, 2013a)*.

The remuneration for offshore wind parks have been auctioned in Denmark already before the Promotion of Renewable Energy Act, since 2005, by the Danish Energy Agency. Until the end of 2015, Denmark had had five offshore wind auction rounds and two more rounds were planned for 2016. The auctions have been held in 2005, 2006, 2008, 2010 and 2015. There is no regular frequency when the auctions are organised. Only one offshore wind farm is auctioned at a time. The location for the wind farm is already pre-defined and only one bidder can win the auction and has to realise the whole project. Prior to the auction, the Danish Energy Agency conducts an Environmental Impact Assessment and a preliminary seabed analysis for the site to be auctioned. In these single-item auctions also the volume of the project is defined, and it varies between the different projects. The bidders compete in price of the bid, i.e. the feed-in tariff they would need to realise and run the project. The bidder with the lowest price wins the bid and is awarded with the bid price, so the auction is a pay-as-bid auction. The support is paid for the first 50 000 full load hours, which accounts approximately for 12-15 years. *(Kitzing & Wendring, 2015)*

Every auction round, however, has had many special features that differ from the other rounds. The first auction round was held in February 2005 and the site Horns Rev 2 was auctioned. The size of the project was 200 MW. The auction consisted of two rounds: during the first round the bidders submitted their first bids, all the bidders filling the prequalification criteria were invited to a meeting with the Danish Energy Agency, and after the meetings the bidders submitted the final bid. As prequalification criteria the bidder had to provide documentation of the company's financial situation and of the previous wind energy (also offshore) projects. Five best bidders were invited to the meetings, whose purpose was to negotiate with the bidders individually about the final bidding round conditions and this way achieve lower bid prices. In this round also some other aspects than price, for example project time plan, were considered, when awarding the winner. The auction was won by DONG Vind A/S, a large Danish energy company, with the price of 51,8 øre/kWh (6,9 c/kWh). No penalties for project delay or cancellation were introduced. The second offshore auction round of the site Rødsand 2 was in May 2006 and the auction features were really similar to the Horns Rev 2 auction. Also this time 200 MW was auctioned and the auction procedure was the same. The winner was this time a consortium of three big energy companies, of which one was the winner of the last round, with the price of 49,9 øre/kWh (6,7 c/kWh). *(Kitzing & Wendring, 2015)*

The Rødsand 2 project was, however, not realised. Therefore, a new auction round for the same project was held in April 2008. The auction procedure was this time changed: There was no negotiations between the bidders and the Danish Energy Agency, but only one final bidding round where the bidders had to submit their first and at the same time final offer. Also no prequalification criteria were required, except a standard criterion of Danish public tenders of the bidder not having over 100 000 Danish krone debt to public entities. The awarding criterion was the price only. The auction winner was a large energy company E.ON Vind Sverige AB with the price of 62,9 ø/kWh (8,5 c/kWh). This time the project was realised. The next auction was held in April 2010 for a 390-400 MW project Anholt. This round had also only one bidding round without negotiations and without prequalification criteria. However, first time in Danish offshore auctions penalties were introduced. There would be a reduction on the support price if the network connection of the first turbine was delayed, and a penalty payment if the network connection of the last turbine was delayed. Both of the penalties were gradually increasing with longer delays. The auction received only one bid. That bidder, DONG Energy A/S, was awarded the project with a price of 105,1 øre/kWh (14,1 c/kWh). As the price was significantly higher than the previous auction prices, an investigation by a third party was conducted and the price was considered reasonable. *(Kitzing & Wendring, 2015)*

The last auction round finished until the end of 2015 was held in February 2015 for Horns Rev 3. The auctioned quantity was 390-410 MW. The two-round auction design with bidder negotiations between the rounds was again introduced for this auction. Additionally, an extensive list of prequalification criteria was to be fulfilled by the bidders. The criteria included for example references to former wind energy projects, minimum annual turnover of 15 billion Danish krone, likely-to-be-used turbine and foundation type and negotiation suggestions for the meeting with the auctioneer. The penalties for delays were this time also applied but changed from the previous round. A gradually increasing penalty payment is applied if the constructing starts too late, and if the network connection of 95 % of the turbines is delayed, the support period is decreased. The auction was won by Vattenfall Wind Power A/S, once again a large company. The awarded price was 77 øre/kWh (10,3 c/kWh). *(Kitzing & Wendring, 2015)*

There are two more auction rounds planned for offshore wind projects. The next round to be held in April 2016 is for nearshore wind projects and after that a round in November 2016 for Kriegers Flak project of 600 MW capacity. The design of the Kriegers Flak auction procedure is again the two-round auction with negotiations in between. *(Kitzing & Wendring 2015)* The prequalification criteria includes for example likely-to-be-used turbine and foundation type and a letter of intent from the financer *(Danish Energy Agency, 2015b)*. The penalties are planned to be the same as in the Horns Rev 3 auction round. In the end of 2015, there were 8 companies applying for prequalification for the auction round. *(Kitzing & Wendring, 2015)*

The nearshore auction round differs a lot from all the previous rounds. In this auction round, 350 MW will be auctioned to several offshore wind farm projects in nearshore areas. There are six predefined areas where it is possible to implement the projects in this round. Several bidders can win in this auction with different projects. *(Kitzing & Wendring, 2015)* On one predefined site, it is possible to have a projects of maximum 200 MW, and also multiple projects on one site are possible *(Danish Energy Agency, 2013a)*. This auction round also first time introduces a ceiling price, 70 øre/kWh. Despite the multi-item auction, the price for the successful bidder(s) will be defined by pay-as-bid rule. As prequalification criteria, references from previous offshore wind projects, minimum annual turnover of 4 billion Danish krone and debt rating requirements are required from the bidder enterprise. In case of project cancellation of a successful winner, a penalty payment is to be paid. If the grid connection is delayed, the support period is decreased. In the end of 2015, there were three bidders for the nearshore auction round. *(Kitzing & Wendring, 2015)*

Additionally, Denmark has an ongoing tendering procedure for 50 MW of test projects of offshore wind technology. The aim of this auction is to allow new technologies, which are ready to be commercialised, to be tested, and by the testing to contribute to lowering costs for the offshore wind electricity production. The sites are not pre-defined as in other Danish offshore auctions, but the bidder has to decide the best site for the particular test and apply for it. Neither are preliminary investigations done by the Danish Energy Agency, but have to be conducted by the bidder. It is, however, possible to build the test turbines in existing test sites or together with a normal offshore wind project. The new technologies or components to be tested can be for example turbine or foundation parts, new ways to operate a turbine or new transmission at the offshore wind farm. The testing cannot be only for pure research purposes but must after the test phase receive new experiences and be able to commercialise the tested technology. As prequalification criteria the bidder has to conduct screening of the planned testing side and provide evidence that the bidder is capable of performing the whole project from receiving the licences and building up the project to operating and decommissioning it. In this auction, the price is not an evaluation criterion but it is fixed at 70 øre/kWh for about the first 50 000 full load hours, and it can be awarded to a maximum of eight turbines per project. Instead, development potential and commercial perspective are evaluated when awarding the winners. *(Danish Energy Agency, 2015c)*

In all the auction rounds, the auction winners have been large companies. Additionally, the other bidders taking part in the auctions were large companies, as well. This was also expected: the nature of the offshore wind projects requires often large companies. Also the prequalification criteria requiring strong experiences in offshore wind projects practically closed out smaller or new actors. *(Kitzing & Wendring, 2015)* In the nearshore auction round, the requirements for the auction were intentionally lowered in order to attract new bidders. Indeed, two of the three bidders in this auction round are new to Danish offshore market. However, these two new actors are also large companies. *(Agora Energiewende & DTU Management Engineering, 2015)* The auction design in all the auction rounds has allowed consortiums to take part to the auctions. If a consortium applies as a bidder, the fulfilment of the prequalification criteria is calculated from all the in the consortium participating actors altogether, not separately. *(Promotion of Renewable Energy Act, 2008)* This way, in theory, also smaller actors might have a possibility to take part in the auction as a part of a larger consortium. This has, however, not yet happened. *(Kitzing & Wendring, 2015)*

Although the real possibilities for smaller actors to participate in Danish offshore auctions are rather small, Denmark pays a lot of attention on the local acceptability of the renewable energy and this way also the possibilities of local people to benefit from the wind projects *(Danish Energy Agency, 2009)*. In the Promotion of Renewable Energy Act from 2008, there were four legal schemes introduced to preserve and improve the local acceptability. The schemes are namely the loss-of-value scheme, the option-to-purchase scheme, the green scheme and the guarantee scheme. In this version of the Act, the offshore and nearshore projects implemented by the tendering procedures were, however, excluded from these obligations. *(Promotion of Renewable Energy Act, 2008).* The parts of the Act concerning the option-to-purchase and loss-of-value schemes were renewed in 2013 and the nearshore auctions were included in the schemes *(Promotion of Renewable Energy Act, 2013)*.

Both of those schemes aim to increase local acceptability of the near-shore turbines: The loss-of-value scheme allows the residents within the distance of up to six times of the height of the wind turbine to receive compensation for the value loss of the property from the wind turbine owner, and the option-to-purchase scheme obliges the wind farm owner to offer at least 20 % share of the wind project ownership to be purchased by local residents. Thus, option-to-purchase scheme can also be seen as a way to include smaller actors in offshore tendering. In this scheme, the local residents have a possibility to buy shares of the winner projects (one person can buy maximum 50 % of the offered shares) and thus also benefit financially when the project makes profit. The local residents are in this scheme defined as the people who have their official residence maximum 4,5 km from the nearest wind turbine of the wind farm. As this rule is a general rule for also onshore wind turbines, it is extended to better fit the nearshore wind farm situation: Any person, who has their official residence in a coastal land in a municipality within 16 km of the wind farm, is allowed to purchase shares of the project. If there are more interest from the above defined people to buy the shares than there are shares, the shares will be divided so that everyone receives first one share, then the persons who were interested to receive at least two shares receive the second share, and so on, until the offered share amount is covered. This way a widest possible ownership distribution is achieved. *(Promotion of Renewable Energy Act, 2013)* The obligation is only to offer the 20 % share to the local residents, not to achieve the 20 % local resident ownership. However, an additional scheme is introduced to incentivise the owners to reach high local ownership percentages. If a local ownership percentage of minimum 30 % is reached, the owner receives additional support payment. The payment is in a form of a supplement to the sold energy price, 1 øre/kWh produced. *(Danish Energy Agency, 2013b)*

As it is clear, Denmark does not design the offshore wind tenders to suit small actors. The offshore wind energy sector, however, is as stated before in the most cases in its nature more suitable for larger companies. As Denmark does not have auctions for any other renewable energy form, it is rather logical not to attract on purpose smaller actors directly to the tendering. However, the small actors are taken into account in tendering indirectly in some cases: the local people are allowed to purchase shares from the nearshore auction winner projects. This way the local people, who are one part of typical small actors, are also involved in some renewable projects resulting from tendering. To conclude the most relevant observations from the Danish renewable auctions from the point of view of small actors, a summary is presented in *table 5*.

Table 5 Summary of the Danish auction experiences from the point of view of small actors.

Technologies	offshore wind
Small actors	no small actors in the auctions, local citizens can buy shares of nearshore wind projects
Experiences	projects mainly realised without delays, local citizen ownership scheme to promote local acceptability of wind projects
Main problems in small actor participation	the nature of the auctioned technology
Recommendations for small actors	if no small actors available because of the technology features, promoting local accessibility by other means possible

4.3 France

France is one of the biggest electricity producers in Europe. The first remarkable renewable energy action in policy-making level was a so-called EOLE 2005 in 1996. The goal of the EOLE 2005 was to improve the French wind energy sector and electricity production from wind in France with targets reaching up to the year 2005. The policy was in force until the year 2000, when a new energy law replaced it. The new law had higher goals for the renewable energy production, also with higher remuneration levels. *(Ruokonen et al., 2010)* In the year 2009 the European Directive 2009/28/EC obliged every EU member country to make a National Renewable Energy Action Plan (NREAP) with renewable energy targets for 2020 and the measures to reach the targets *(European Council, 2009)*. The renewable target for France was set to be 23 % of the total energy consumption and 27 % of the electricity demand *(NREAP France, 2010)*. These targets are technology-specific divided as following: 19 GW onshore wind, 6 GW offshore wind, 5,4 GW solar power and 2,3 GW biomass total capacity until 2020 *(IEA Wind, 2015)*. These targets were updated in 2015 in Energy Transition Act to reach to the year 2030. The renewable share of the total energy consumption should be 32 % and of the electricity demand 40 % in 2030. *(Energy Transition Act, 2015)* In 2014, the renewable share of the country's electricity demand was 19,5 %. The largest renewable technology in France is hydropower, and also wind, solar and biomass-based technologies contribute to the renewable electricity production share. *(IEA Wind, 2015)*

Renewable energy auctions have taken place in France since EOLE 2005, as the first tendering round was organized in 1996. As EOLE 2005 was introduced for wind power promotion, also the first auction round was organized for wind power projects. Altogether 50 MW of onshore wind power were tendered by the Ministry of Industry and Environment and Energy Management Agency in two categories: 15 MW for projects with already finished wind measurements on the site and 35 MW for projects with installed wind measurement devices on the site. As the goal of the EOLE was not only to achieve cost efficiency of the wind energy but to also improve the whole wind energy sector in France, price was not the only awarding criterion in the auction. In addition to the price of the bid, also economic advantages of the project, long term benefits of the technology, technical and financial reliability, environmental issues and local authorities' opinion of the bids were evaluated. Also technological and regional diversity were considered when awarding the auction winners. The winning projects were compared to nowadays' wind project sizes rather small, between 0,6 and 7,2 MW. The average price of the awarded projects was 5,2 ECU cents/kWh (ECU was the calculatory European monetary unit before euro and its value equalled to euro). *(Laali & Benard, 1999)*

Until the year 2000 and the termination of the EOLE 2005 program, altogether 55 projects with a total volume of 361 MW were contracted as a result of several tendering rounds for wind energy *(Ruokonen et al., 2010)*. However, only about 20 % of the contracted projects were in the end realised, resulting in only 70 MW increase in wind energy in the EOLE 2005 program *(del Río & Linares, 2014)*. The new renewable energy policy in 2000 changed the main renewable remuneration system from tendering to feed-in tariffs. In this system for example wind energy receives 8,2 c/kWh for the first 10 years and depending on the wind conditions 2,8 to 8,2 c/kWh for the following 5 years. To be able to increase the renewable energy share into the target levels, France launched a so-called multiannual programming of investment (Programmation Pluriannuelle des Investissements, PPI), which sets the targets for renewable energy by technology. The PPI scheme allows the government to release calls for tenders to complete the new renewable energy building targets if the feed-in tariff scheme does not lead to desired renewable levels in a specific technology. Within the PPI scheme, tendering procedures are organised when needed to assure achieving the objectives. The auctions are organized by the Energy Regulation Commission (Commission de régulation de l'énergie, CRE) in cooperation with the Ministry of Energy. *(Ruokonen et al., 2010)*

The auction design in the PPI scheme varies between the different renewable technologies and rounds, but some basic principles are in common with the various rounds. There are two main types of tendering procedures in the PPI scheme: a normal procedure with extensive bids and multi-criteria evaluation and a fast online procedure with more compact bids and only quantitative evaluation criteria. *(CEER, 2016)* The call for tenders defines the desired increase of the specific technology in different regions and also to some extent in plant sizes and amounts in a region. As prequalification criteria the bidders have to provide the supply contract for the fuel (in biomass tenders), pre-study on the grid connection, other possible studies conducted and an ownership or rental contract for the planned site. The auction is a pay-as-bid auction and the price will be paid typically for 20 years. There are several awarding criteria to select the winners; price is always evaluated and the other criteria depend on the auction round and the auctioned technology, though they are often similar to the EOLE selection criteria. If the project is delayed or failed, there are penalties in form of decrease in the support period or a penalty payment. *(Ruokonen et al., 2010)* After the bids are submitted, in case the auctioneer considers the competition level too low to achieve cost efficiency, it may cancel the auction *(CEER, 2016)*.

The first PPI tendering round was organised in 2003 for covering peak electricity demand on one French island *(Ruokonen et al., 2010)*. After that, until the end of the year 2015, there had been many additional rounds for different technologies: onshore and offshore wind, biomass and solar power. In 2004, one round for biomass and one round for offshore wind were organised. The next round was for onshore wind in 2005. A round for biomass was again organised in 2007. The years 2009 and 2010 experienced both two rounds, one for biomass in both years and in 2009 one for PV over 250 kW and in 2010 one for onshore wind with batteries. Until 2011 the auction rounds had been irregular, and as the PPI suggested, used to balance the differences between the renewable targets and by feed-in tariff implemented capacities. In 2011, however, more regular tendering rounds started for PV and offshore wind technologies. Thus, there was one offshore round in 2011 and 2013 each, and several, foreseeable rounds for PV installations since 2012. The change to more regular rounds were made in case of PV technology because of a failed auction round in 2009. As the power producers could also receive remuneration with a normal feed-in tariff, the tariff level appeared to set the minimum price for the bidders as no one wanted to bid for a worse price as what they could receive without a hard bidding procedure. This resulted in too high bidding prices and the auction round was cancelled. Since then, auctions are the main remuneration method for medium (100-250 kW) and large (over 250 kW) scale PV installations and thus organised on a more regular basis. *(CEER, 2016)* The following paragraphs describe as examples closer some of the auction procedures organised since 2000.

The tendering round for biomass organised in 2007 auctioned 200 MW to projects larger than 9 MW and 80 MW to projects between 5 and 9 MW. In addition to the above mentioned prequalification criteria, the bidders had to provide also specifics about the technology and equipment to be implemented and energy production estimates. The bids were evaluated based on the price, biomass supply plan, energy efficiency and technical and financial capabilities of the bidder. The support was contracted from the commissioning date until the 1st of January 2030. This round received a total of 56 bids with a total volume of 692 MW. Only one bidder did not fulfil the prequalification criteria. Altogether 22 bidders were awarded as winners, 84,6 MW for the smaller projects and 229,8 MW for the larger projects. The average price of the winning projects was 128,1 €/MWh. *(Ruokonen et al., 2010)* Since then, the PPI scheme has experienced also significantly lower prices: for example, the average winning price of the tendering round in 2009 was only 45 €/MWh *(del Rìo & Linares, 2014)*.

The first round of offshore wind tenders in 2004 failed in project realisation, as in the end no project awarded in the auction was realised. This was stated to result from many local issues. The offshore wind target being as high as 6 GW by 2020, the government realised that more and better designed auctions have to be organised. Therefore, before the next round organised in 2011, the government decided with local authorities six offshore wind zones for the coming auctions. Two of the sites were awarded in 2011 round and the rest, 4 sites, in 2013. The evaluation was conducted in both rounds again by multiple criteria, for example price, industrial development, environmental aspects and research and development contribution of the project. The rounds did not receive a lot of bids and there were only two bidders for an auctioned zone on average, thus leading to a low competition level. One zone had to be cancelled from the auction as it received only one bid. The low competition led to relatively high average winning prices: in 2011 the average price was 220 €/MWh and in 2013 a bit lower, 200 €/MWh. In addition to low competition level, also high risks for the bidders in form of technical uncertainties during the auction time (when the project specifics have to be defined without knowing the exact conditions on the site) and a focus also on research and development might have increased the bid prices. *(CEER, 2016)*

As stated, the PV auctions have been organised more frequently and foreseeably since 2012. In 2011, CRE published a call for tenders for medium-scale rooftop PV installations. This call included seven rounds: five rounds spread over the year 2012 and two for the beginning of 2013. In 2013, one more round for the end of 2013 and two rounds for 2014 were announced. Additionally, in the beginning of 2015 one round for 2015 and two rounds for 2016 were published. Also large-scale PV auctions have had more frequent rounds since 2011, though not as frequent as the medium-scale PV auctions. Rounds have been organised in 2011, 2013 and 2014, and additionally a round for medium- and large-scale PV installations in non-interconnected regions was organised in 2015. *(CRE website, 2016)* Tenders for the medium-scale PV plants were organised as fast online procedures, thus simple for the bidders *(CEER, 2016)*. As prequalification criteria, the bidder had to be the owner of the building where the installation was planned to be built and a carbon dioxide

(CO_2) assessment and a statement of recycling of the installation after its lifetime had to be submitted along with the bid. The CO_2 assessment was also a part of the evaluation criteria, contributing to 33 % of the evaluation, whereas the price of the bid contributed to the rest. The support (i.e. the bid price for the successful bidders) is paid for 20 years, and 80 % of it is fix and 20 % indexed. The projects had to be realised in 18 months. In case of delays, the support period could be shortened. All the rounds in 2012 received a lot of bids compared to the auctioned capacity. However, many bids did not pass the prequalification criteria in the first year's rounds, which resulted in low competition level and higher prices than expected. The prequalification criteria were recognised to be challenging and also the instructions for that insufficient. Therefore, the auction rules were re-designed for the next rounds and thus the two first rounds in 2013 cancelled. *(Held et al., 2014)* The re-design functioned, and the prices decreased from the highest average price of 2012 rounds, 232 €/MWh, to the lowest average price of 2013 rounds, 153 €/MWh. The large-scale auctions were also successful and resulted in varying PV technologies: rooftop installations, ground-mounted plants as well as systems utilising concentrated solar technology were all successful. *(CEER, 2016)*

The suitability and friendliness of the French tendering rounds for small actors have varied a lot, depending on the type and design of the auction round. The EOLE 2005 scheme did not encourage small actors to participate in the auctions. Quite on the contrary, the EOLE auction rounds attracted large international wind companies, which started their dominance in the French wind markets. *(Ruokonen et al., 2010)* One of the most significant benefits of taking small actors into account, public acceptance, was, however, also in EOLE scheme contributed by requiring a certain regional distribution in the successful bids *(del Río & Linares, 2014; Ruokonen et al., 2010)*. The PPI scheme, as well, was stated to be unsuitable for small actors because of the high expenses of putting up the tender *(Ruokonen et al., 2010)*. Another concrete issue emerged in the newer, 2011 and 2013 offshore wind tender rounds. The time between the announcement of the auction round and the deadline for submitting bids was in 2011 six months and in 2013 nine months. As offshore wind farms need extensive measurements before actually installing the farm, those time frames were too short for the whole measurement and bid processing operations. Thus, the bidders had to already have conducted some preliminary measurements on the sites to be able to submit possibly successful bids. This prevented new market players from participating in those auction rounds. Often the small actors are also new actors, thus, this was an additional obstacle for small actors in these offshore tendering rounds. *(CEER, 2016)*

Even though the most of the French renewable auction rounds have not been suitable for small actors, there are also some positive experiences. In fact, the medium-scale rooftop PV auctions were especially intended for smaller actors. The simple online system with no financial guarantees was designed for private building owners. The call for tenders managed to reach high interest in the target group and received a lot of bids. However, as stated before, a high amount of bids in the first five rounds had to be neglected because of not fulfilling the prequalification criteria. The prequalification criteria included CO_2 assessment, which is a hard task for a private, not energy technology oriented person without experience in such actions. Therefore, the prequalification criteria and the whole design of the auctions was renewed and simplified to better suit the needs of small actors. *(Fraunhofer ISI et al., 2014; Held et al., 2014)*

All in all, France has a wide experience in organising renewable energy auctions. Some of the organised rounds have been successful in several means, some have failed in some aspects. From the point of view of small actors, only the later PV auction rounds have been attractive and possible to participate. Until now, there have not been any signs in other technologies' auctions to especially design them to ease the participation of small actors. However, if the medium-scale PV auction trend continues as it has been for the last three years, this sector offers possibilities for small actors to be active in the renewable energy auctions in France. To conclude the most relevant observations from the French renewable auctions from the point of view of small actors, a summary is presented in *table 6*.

Table 6 Summary of the French auction experiences from the point of view of small actors.

Technologies	wind onshore & offshore, biomass, solar PV
Small actors	only in the latest solar PV auctions
Experiences	the former schemes did not attract small actors, the latest solar PV auctions attract many but had to be simplified in order to allow them to be successful
Main problems in small actor participation	in PPI scheme: high costs for preparing the bid, in the latest solar PV auctions: too complicated prequalification criteria in the first rounds
Recommendations for small actors	as simple design as possible, online, no financial guarantees, no complicated prequalification criteria

4.4 The Netherlands

The Dutch energy system is characterised by gas- and coal-fired power plants. In 2011, only 4,3 % of the total energy consumption in the Netherlands was produced with renewable energy sources and in 2013, 9 % of the installed power capacity was renewable energy capacity. The renewable target for 2020 is therefore for the Netherlands rather ambitious – the renewable share of total energy consumption should be until then 14 %. *(Bayer & Baker, 2014)* In 2003, the Netherlands started with a feed-in premium-based remuneration to the renewable energy technologies. The premium level was predetermined, dependant on the technology and paid for the ten first operation years on top of the market electricity price. The premium level was set every year to suit the development on the technology prices. The implementation of new renewables increased significantly, and in 2005 there was not enough budget for more support, so the premium level was set to zero for biomass and offshore wind. The government believed in reaching the renewable targets with already contracted capacity. However, in 2008, new and more ambitious renewable targets, 14 % by 2020, were set, and the Dutch government had to re-think the remuneration methods. Therefore, in the same year, the Sustainable Energy Incentive Scheme (Stimulering Duurzame Energieproductie, SDE) was implemented to be able to reach the new objectives. It was also a feed-in premium system, where the premium level was calculated on a yearly basis for PV, biomass, hydropower and onshore wind. In the premium level calculation, the possible average incomes of a renewable technology producer were subtracted from the average production costs of a specific renewable technology. The support was allocated to the projects every year until the yearly budget of a technology was exhausted. In the SDE scheme, offshore wind support was auctioned. *(Ruokonen et al., 2010)*

In 2011, the SDE scheme was updated to an SDE+ scheme. SDE+ is an auction-based support scheme, where auction winners receive a floating premium for the energy production. The goal of the SDE+ scheme is to achieve the 2020 targets with the least costs. *(Held et al., 2014)* The SDE+ differs from the SDE in an objective-setting sense so that it focuses on the short-term renewable implementation on only 2020 targets, whereas the SDE was focusing on longer-term implementation and also innovations. There is an overall annual budget for the scheme, and when the budget is exhausted, no more support is allocated to renewable energy under this scheme in that year. The budget is covered by the electricity consumers, which is a new model in the Dutch renewable remuneration – in the earlier schemes the support was financed by taxpayers and the government budget. *(Winkel et al., 2011)* The budget was for 2011 1,5 billion euros, for 2012 1,7 billion euros, for 2013 3 billion euros and for 2014 and 2015 3,5 billion euros *(Held et al., 2014; NL Enterprise Agency, 2015a & b)*. The SDE+ scheme does not only offer support for renewable electricity, but also for biogas fed into the Dutch natural gas network and renewable heat or combined heat and power (CHP) production *(NL Agency, 2012)*.

In addition to the SDE+ scheme, the Netherlands has at the moment also other support schemes for minor renewable projects. Many different tax incentive schemes are in force in order to support projects, which cannot receive support from SDE+ scheme. One of the tax incentive schemes is the Tax Deduction Scheme. In this scheme the renewable energy projects are allowed to deduct a maximum of 41,5 % of their total investment costs from the profits of the installation year in taxation. There are caps per technology for this subsidy, but on average 10 % of the investment costs can be covered through this scheme. The Tax Deduction can also be applied when receiving SDE+ subsidy. *(Winkel et al., 2011)* An additional tax incentive scheme is the Environmental Investment Rebate, which offers a tax refund for all the entrepreneurs who invest in a technology contributing to environmental friendliness. Another scheme, Arbitrary Depreciation of Environmental Investments, allows the entrepreneur to depreciate the investment in accounting when the entrepreneur wants to. The investments eligible for the two schemes are listed in an Environmental List, which is updated annually by the Ministry of Infrastructure and the Environment. *(NL Enterprise Agency, 2014)* As the SDE+ scheme does not contribute to innovation in renewable technologies, there are for example financially supported initiatives and innovation projects to develop technologies further and this way achieve cost reductions in renewable technologies by innovation. These schemes are applied for example to offshore wind energy, as it is at the moment still one of the most expensive renewable technologies. *(Verhees et al., 2015; Ministry of Economic Affairs, Agriculture and Innovation, 2011)*

The renewable energy auctions have been held in the Netherlands since 2010. The first auction round was organised under the SDE scheme and 950 MW of offshore wind power was tendered. The bidders had to already in 2009 apply for required water permits. Along with the bid, the bidders had to submit also the water permit, the planned plant distance to the shore, project timetable and financial calculations of the project. The bid prices in costs per energy produced were evaluated and the lowest cost projects were awarded with their bid price, which was a floating premium on the top of the electricity market price. In sense of the support sum the project owners receive, a floating premium is equivalent to a feed-in tariff. *(Ruokonen et al., 2010)* The premium was contracted for 15 years of operation. The projects were supposed to be awarded until the pre-defined budget, 4,5 billion euros, was exhausted, and the 950 MW was a capacity cap. *(Verhees et al., 2015)* The awarded projects had to be realised in 5 years, and in case of a project cancellation or delay a penalty of 20 million euros was to be paid. The water permits of the projects not winning the auctions were cancelled. *(Ruokonen et al., 2010)* There were altogether twelve eligible bidders for this auction round, mostly large foreign companies. The auction was won by two German projects, both of a subsidiary of one large German company. The projects were both 300 MW of size and it was noticed that the budget would not cover all the planned 950 MW of new capacity. *(Verhees et al., 2015)*

As the SDE+ scheme changed the main renewable subsidy method to auctions, tendering rounds have been organised regularly since the change. As the objective of the SDE+ program is to achieve the renewable increases as cost-efficiently as possible and there is a general, not technology-specific budget cap annually, the different renewable technologies are competing against each other in price and only the cheapest ones are realised. *(Ministry of Economic Affairs, Agriculture and Innovation, 2011)* The auction is basically a volume auction with a dynamic, ascending clock auction mechanism. The government announces annually an auction with several rounds. Each round has a so-called base amount, that is the price of the round. The base amount increases every round. There are as many rounds organised as there is still budget left. The bidders bidding already in the early rounds thus receive a lower subsidy, but the bidders waiting for the later rounds with higher support levels have the risk of budget exhausting before those rounds and not having a chance to bid at all. *(Held et al., 2014)* The auction system is technology neutral in that sense that all the technologies take part in the same auctions and compete for the same budget. However, in every round, the base amount is calculated for each technology separately. That means that every technology has a different base amount in one round, thus the auction design avoids windfall profits. There is always also a free category for the technologies which do not have their own category, typically more expensive technologies like offshore wind energy and small-scale PV. The free category offers a chance also for innovative, cost-reductive projects without specifying the technology. *(Winkel et al., 2011)* The base amount for each technology is calculated annually based on the expected renewable energy costs and energy price. The budget needed as remuneration for a project is calculated with the base amount, subsidy period, nominal capacity and maximum or estimated full load hours. As this reflects the production volume of the project, this feature makes the auction a volume auction. *(NL Agency, 2012)*

For every year of SDE+ scheme auctions, a table with all the rounds, technology categories and respective base prices are published. For example in 2012, onshore wind, hydro power, waste water installations, biomass-based biogas production plants including biomass gasification, CHP or heat production from biomass, geothermal, solar thermal and heat expansion for existing waste incineration plants had their own categories, some in all the rounds and some only in the later rounds. The rest of the acknowledged technologies, namely offshore wind, solar PV, osmosis and free flowing energy had to compete in the free category. *(NL Agency, 2012)* Free flowing energy includes in this case tidal and wave energy and energy from water, which is not especially pumped for this purpose and where the drop is under half a meter. Osmosis energy produces electricity by differences in salt concentration in two bodies of water, for example when a river flowss to the sea. This technology has, however, until now only pilot plants in operation. *(NL Enterprise Agency, 2015b; Kempener & Neumann, 2014)* The technologies with own categories and eligibility to participate in free category are revised every year. The bidders have to submit as prequalification criteria possible required permits (for example water permits) and permission of the owner of the planned location. Each round has a deadline until when the bids for that round have to be submitted. However, the bids are awarded on a daily basis also before the deadline with a "first come, first serve" principle, and in case of exceeding the budget by bids arrived on a same day, the lower base price category bids are preferred. This means that the price is the only evaluation criterion. *(NL Agency, 2012)* The winners are awarded with the support for 5, 8, 12 or 15 years of operation, depending on the technology *(NL Enterprise Agency, 2015b)*. There are also varying realisation time periods for different technologies: from 18 months for expansions in existing plants to 5 years for offshore wind projects. In case of non-realisation or delay, for projects with a total budget of over 400 million euros, a penalty of two percent of the project budget is to be paid. *(NL Agency, 2012)*

Already in the first years of SDE+ scheme, one of the main goals of the scheme, cost reduction in renewable subsidies, was achieved. The former SDE scheme needed 80 % more budget for the same renewable increase than the SDE+. This is partly caused by the competitive nature of SDE+, but also because renewable heating, which is generally cheaper than renewable electricity, was included in the newer scheme. The competition led to cancellation of the later rounds: in the first year, 2011, almost the whole budget was allocated in the first round, and in the second year, 2012, the whole budget was exhausted in the first round. *(Held et al., 2014)* The following years 2014 and 2015 have also been efficient in allocating production licenses for a large number and remarkable capacity of renewable projects for low costs: in the year 2014, over 4000 bids were received, of which a bit over 3000 projects were awarded, and in the year 2015, 194 of the 777 bids were successful *(NL Enterprise Agency, 2015a; Rijksdienst voor Ondernemend, 2015)*.

As already mentioned, the first Dutch renewable auction round with offshore did not attract any small actors. This is, however, not necessarily a sign of a bad auction design, but rather a feature of offshore wind projects, as mentioned in subchapter 4.2 Denmark. Therefore, the SDE+ tenders are more interesting from the point of view of small actors in Dutch renewable auctions. In principle, no actor groups are excluded from the SDE+ auctions. It is also mentioned in the calls for tenders that the scheme is aimed not only for companies but also for institutions and non-profit organisations. *(NL Enterprise Agency, 2015b)* The design of the tendering system, however, is in no official auction documents stated to be made to suit small actors. Quite on the contrary, as already the main goal of the tendering system is to achieve the renewable increase at the lowest possible costs, the starting point is not optimal for small actors. Indeed, as the auction budget has in many years already been exhausted in the early, low-subsidy level rounds, small actors might have had less chances to participate economically feasibly than the large companies. *(Rijksdienst voor Ondernemend website, 2016)* However, in the Dutch renewable auctions the high competition level and achievements in cost reductions seem not have hindered small actors to participate. According to Gephart and Kitzing *(2016)*, the percentage of small and medium sized companies taking part to the SDE+ auctions has been in the years 2011 to 2015 between 67 and 85 %. Moreover, the participation of organisations, communities and other related actors has been 11 to 20 % of all the participants. Only very little percentages have been large, multinational companies.

On the website of the auctioneer, there are lists of the results and awarded projects available. According to those lists, many limited liability companies, which often are relatively large actors, have been successful in the auctions. However, the lists include also, depending a bit on the year, many anonymous actors. The anonymous ones are stated to be partnerships or other forms of enterprises where the individual persons can be easily identified. Those kind of enterprises are supposedly (though not stated clearly in the lists) in the most cases small actors, and thus, the Dutch SDE+ auctions have not only attracted many small actors to participate but also have the small actors been successful. The most of these anonymous actors appear in the solar PV category, but some have also been successful in onshore wind, solar thermal, biomass and biogas projects. *(Rijksdienst voor Ondernemend website, 2016)* Also a report of Dutch citizen energy cooperatives states the SDE+ scheme to be the main support scheme for cooperative solar power projects, even though there are also some other means of support that could be taken use of. Until the end of 2015, 3,1 MW of cooperative-based renewable energy projects were realised with a subsidy allocated from SDE+ auctions. *(Schwencke, 2016)*

The Dutch renewable energy auction system is still relatively young, but has already gathered some experiences. It seems that the system is efficient in cost reduction, but there are doubts if the country is actually able to achieve the 2020 targets with the least-cost method and the SDE+ scheme. *(Held et al., 2014)* The auction scheme is also not especially designed for small actors. However, it seems that also many smaller actors, for example cooperatives, are nevertheless able to participate and succeed in the auctions. To conclude the most relevant observations from the Dutch renewable auctions from the point of view of small actors, a summary is presented in *table 7*.

Table 7 Summary of the Dutch auction experiences from the point of view of small actors.

Technologies	wind onshore and offshore, solar PV, solar thermal, geothermal, biomass, hydro
Small actors	aimed at all actor groups, not especially designed for small actors but to achieve least cost renewable expansion
Experiences	surprisingly, the most of the bidders small actors and also many of them successful (in solar PV and thermal, onshore wind and biomass)
Main problems in small actor participation	no identified problems
Recommendations for small actors	simple design, own price for each technology, no excessive prequalification criteria

4.5 Brazil

Brazil is a geographically large country with metropolitan cities and vast areas in the Amazon jungle, which are almost untouched by the humans. The geographical diversity and size make the electricity system of the country also large and rather complicated. The Brazilian power system has always been characterised by the dominance of hydro power: in 2011, 80 % of the installed electricity production capacity was hydro power plants, and 90 % of the electricity demand was covered by hydro power. *(Rego & Parente, 2013)* The hydro power plants are spread over the country and have large water reservoirs, which can hold water for several years' hydro power production needs. Thus, the electricity price in Brazil is much influenced by the water reservoir levels: in dry years or periods, the electricity prices are significantly higher than in years with enough rain. *(Mastropietro et al., 2014)* The Brazilian power system is divided into four submarkets: North, Northeast, Southeast/Midwest and South *(Moreno et al., 2010)*. One remarkable feature of the Brazilian electricity markets is the dominating position of one company, Electrobras, and its subsidiaries. The company was originally founded in the 1960s as a state company to develop and operate the Brazilian energy system. Since the unbundling of the system, the power of Electrobras has weakened but is still a remarkable and relatively dominating part of the energy markets, both in generation and transmission. Because of its size in the Brazilian electricity markets and the ownership distribution, where almost half of the shares belong to the Government of Brazil, there are concerns about the company's market power in the present, liberalised electricity markets. *(Rego & Parente, 2013)*

In the past few years, the percentage of hydro power in Brazil has been decreasing significantly and the generation is replaced by other, both fossil and renewable, energy sources. In year 2014, the hydro power percentage of electricity generation was only 63 %, much less than three years earlier in 2011. *(Gallo & Lobianco, 2015)* As Brazil already had a huge share of renewables in its electricity production mix in form of hydro power, it is a relevant issue to justify why it is necessary to promote renewable energy in other forms further in the country and decrease the importance of hydro power, a simple renewable source in Brazilian conditions. When the power system is dependent almost only on hydro power, it is also automatically dependent on rainy and dry periods or years. As the tropical rains are sometimes hard to forecast, the system adequacy has to be kept stable on conditions of the varying water levels and all the other power plants run only when the water reservoirs are not full enough. The recent history has shown a few examples of critical situations, where the reservoir levels have been too low and the capacity of other power plants has not been enough or was near to its limits replacing the hydro power. *(Corrêa da Silva et al., 2016)* In 2001, the drought caused a serious lack of hydro power capacity. The other power plants at that moment available were not able to back up, and the supply not covering the demand led to power rationings of about 20 % for over half a year. *(Rego & Parente, 2013)* The past few years have also experienced exceptionally little rain and the whole country has therefore had very dry conditions. Therefore, Brazil has again been going towards electricity crisis when the hydro reservoir levels have decreased. In the beginning of 2015, the water reservoir levels were lower than in the time of 2001 crisis. This led, however, only to one day of power rationing because the power system has been developed towards less dependence on hydro power. *(Corrêa da Silva et al., 2016)*

In Brazil, the energy sector liberalisation started in 1993. After almost ten years of privatising generation, transmission and distribution units, the 2001 electricity crisis led to a re-thinking of the energy reform to better mitigate the problems caused by hydro power dependence of rain conditions. The energy reform system was renewed in 2004 and included significant changes to the old system. One of the biggest changes to the old system was the creation of two electricity market environments, regulated contracting environment for small, captive customers and free contracting environment for large, free customers. In the free contracting environment, the electricity producers and consumers negotiate bilateral energy supply contracts. For the regulated contracting environment, an auction system for allocating power plant construction and operation allowances was designed. In the renewable energy auction context, Brazil is in a sense of auction goals an exception among the other countries analysed in this thesis. When the regular auctions in the energy sector started in Brazil in 2004, their purpose was to ensure sufficient electricity supply for the growing economy and prevent situation like the rationing in 2001, and they were also applied to fossil fuel-based energy production. Thus, the energy auctions have not originally been used in Brazil to support renewable energy but to control the amount of electricity produced generally. *(Rego &Parente, 2013)* The first attempt to promote renewable energy, i.e. wind, biomass and small hydro power, was a feed-in tariff scheme started in 2002. The remuneration was awarded under this scheme in “first come, first serve” principle and not on the least-cost basis. The scheme failed in several aspects, for example in reaching its expansion goals, incentivising economic efficiency and technological development, and created in the end bottlenecks in some project phases of renewable energy projects. Thus, the scheme was terminated in 2011 and the auctions became the only remuneration method for renewables in Brazil. *(Elizondo Azuela & Barroso, 2012; IEA website, 2016a)*

In the Brazilian energy auctions, the Chamber for Commercialisation of Electrical Energy (CCEE) acts as the auctioneer. The responsibility of estimating the required auction amounts is, however, shifted to the distribution utilities who are to buy the electricity produced by the successful bidders, i.e. the generators. All the distribution utilities have to estimate before an auction round how much power they need to have contracted in the next years and the summed amount of all distribution utility needs is auctioned. The auctions are not only used to tender new power plants but also to contract the energy produced with already existing plants. Thus, the energy auctions in Brazil resemble in that part electricity markets where the electricity produced is auctioned and the price for electricity is decided by the market situation. To ensure the electricity supply security, the distributors have to have firm energy certificates to cover their estimated electricity needs. If the estimated and actual demand do not match, the distributors have to pay penalties. This way the system requires accuracy in future energy demand estimations and can in an effective way ensure that there is enough supply to cover the demand. *(de Souza & Legey, 2010)*

As mentioned, there are auctions for both new and existing energy. In this system, they compete in different auctions and not against each other. Several different kind of auctions are organised for varying purposes: so-called A-5 and A-3 auctions for new energy, A-1 auctions for existing energy, adjustment auctions and auctions for some special projects. The A-5 auctions are organised five years before the contracted operation starting time of the power plant. The auctions are especially meant for new hydro power plants, considering the required building time of such a plant. The contracts in A-5 auctions are very long-time contracts, 30 years. A-3 auctions are, accordingly, held three years before operation beginning. They are designed according to thermal power plants' construction time and the contract duration is 15 years. *(de Souza & Legey, 2010)* Wind energy is an exception with the contract duration: it is awarded with 20 year contracts in both A-5 and A-3 auctions. Both A-5 and A-3 auctions are held regularly once a year. *(David et al., 2013)* The objective of both of these auctions is to meet future energy demand by adding power production capacity. The A-3 auctions have also a function as a possibility for the distributors to correct the estimation made in A-5 auctions. On the other hand, the A-1 auctions are intended for already existing power plants and organised one year prior to the contract beginning. The contracts last five to eight years in A-1 auctions. The purpose of these auctions is to replace the energy supply contracts expiring. The adjustment auctions are also designed for existing energy, and as the name tells, are purposed on adjusting on shorter term the made estimations. The electricity delivery of the adjustment auctions is to start in four months after the auction is held and the contracts last three months to two years. Special auctions have been held for some particularly large hydro power projects in the Amazon region. *(de Souza & Legey, 2010)*

The auction mechanism is a hybrid model of static and dynamic auctions. The auction has two stages, first stage being a descending clock auction round and the second stage a sealed-bid round. At first, the auctioneer announces a price high enough to attract many bidders with more quantity than the actual auctioned quantity. The bidders submit their bids in terms of energy they would be able to supply with that price, in average megawatts (i.e. the amount of energy produced per year divided by 8760, i.e. the amount of hours in a year). Next, the auctioneer lowers the price and the bidders submit their bids again with average megawatt amount according to the now announced price. These rounds continue until the bids reach a so-called reference offer, which is a beforehand calculated value of bid amount that is still higher than the actual auctioned amount and ensures competition for the second, sealed-bid stage. In the second and final stage, the bidders qualified from the first stage now have to submit their final offer in terms of price. The price cannot be higher than the price of the last round of the first stage. The winners are the bids with lowest prices until the auctioned amount is covered, and they are awarded with their bid price. This kind of hybrid design mitigates the problems of a pure static or a pure dynamic auction: the first stage allows for price discovery and reacting to competitors' behaviour, which in a pure static auction is not possible, and the second stage prevents collusive behaviour of the bidders, which is in a dynamic auction more likely than in a static one. One purpose of the second stage is also to achieve cost reductions through the high competition in prices. *(Rego & Parente, 2013)*

In theory, all technologies are allowed to take part in all the auctions. However, as mentioned before, for example hydro power plants require in the most cases five years' construction time and thus cannot compete in A-3 auctions. In addition, the auctioneer has in some auction rounds restricted some technologies, for example oil or coal fired plants, not to be eligible to take part, or assigned an auction round only for renewable technologies. *(David et al., 2013)* The auction prequalification requirements include a granted environmental license, a grid study proving feasible grid connection point for the power plant and a financial guarantee of one percent of the project investment costs. Additionally, if the project is successful in the auctions, another financial guarantee of ten percent of the project costs is to be deposited after awarding the winners. Both of the financial guarantees are to ensure that the projects awarded are actually realised, and in case of project failure or delay, there are penalties to be paid or the contract can be terminated in case of a delay of more than one year. Wind energy projects have some additional prequalification criteria: the wind turbines used have to be new ones and wind measurements at the proposed site have to be conducted by an independent party at least for 12 months. *(Elizondo Azuela & Barroso, 2012)* The awarded contracts are allowed to be traded after the auctions. This has created a secondary market for the winning bids. *(Held et al., 2014)*

Brazil has, however, also energy auctions, which do not necessarily follow any of the before mentioned rules. In addition to new and existing energy auctions, Brazil organises reserve energy auctions as well. These auctions are organised directly by the government. The government can call an auction when it considers a need to more reserve energy capacity or decides to promote a special energy source. Thus, the reserve energy auctions are not organised according to the future energy demand estimates of distribution companies but to the decision of the government. These auctions can have varying rules each time, as the government can decide the proper rules separately for the specific round. It can also decide freely the auctioned amount and the possible technology restrictions. *(Maurer & Barroso, 2011)* In practice, however, the reserve energy auctions have been implemented with the most of the features of the regular energy auctions *(Elizondo Azuela, 2014)*. The most significant difference to the regular auctions is that the contracts signed in reserve energy auctions do not have to have firm energy certificates to cover their supply. *(Maurer & Barroso, 2011)*

The first Brazilian auction awarding renewable energy projects other than large hydro power plants was held in 2007. Since then, until the end of 2015, altogether 21 auctions for renewable energy have been conducted. *(IEA website, 2016b)* The auctions, where renewable energy sources have been competing, have been either regular new energy auctions or reserve energy auctions. The auctions have been able to attract many bidders and thus create a competitive environment. Especially the onshore wind energy sector has been growing fast in Brazil due to the auctions. As there was only very little wind power in Brazil before the first auction aimed only for wind projects in 2009, the best and windiest sites were still available. Furthermore, wind projects could receive very generous financing conditions from the Brazilian national bank and additionally the weak economic situation in Europe attracted many international investors to other countries, for example to Brazil. To promote wind energy even more, the calculation method of the maximum offered energy of a wind turbine was set to an optimistic model instead of the traditionally used ones. High competition and good conditions for wind power led to lower prices than expected. *(David et al., 2013)* The average price of wind power decreased in the 2009 auction 45 % of the prices under the old feed-in tariff scheme, and during the next two years the prices dropped 40 % more *(Elizondo Azuela et al., 2014)*. In 2011, wind power competed against conventional energy sources in an auction and reached prices lower than the other technologies in the auctions *(David et al., 2013)*. Since then, wind energy has been driving down the auction prices and generator profits for other technologies in the Brazilian technology-neutral auctions, which is an exceptional situation worldwide *(Elizondo Azuela et al., 2014)*.

The high price reductions, however, have raised concerns about projects' economical sustainability and the bidders' ability to realise the projects. It is stated, for example, that the capacity factors in submitted bids are estimated too high and that the actual production will stay smaller. As the auction winning prices have been decreasing, the auctioneer has also decreased the ceiling price accordingly. In the end of 2013, the ceiling price was already set that low that the auction participants could not bid lower than that, resulting the winning price to be the ceiling price, thus reducing competition. As the prices received from the auctions have dropped that much, the risk of delays in the projects' realisation increases. Indeed, in 2013, as many as 70 % of the projects, which should have had started operation, were over one year delayed. However, not only construction problems, possibly caused by too low prices, but also transmission network connection problems have been causing delays. In fact, 70 % of the delays were caused by grid connection delays. *(Elizondo Azuela et al., 2014)* For example in 2013, 50 wind farms totalling to over 600 MW were ready to start operation but missing the grid connection and therefore having delays in commissioning *(David et al., 2013)*. Because of these problems, the conditions for wind power projects to participate in the auctions were revised in 2013. The calculation of maximum energy offered by a wind turbine was set to the conservative, more realistic model. Also the grid connection problems were mitigated by transferring more responsibility on the transmission grid accessibility to the power plant investors. *(Elizondo Azuela et al., 2014)* There has also been discussions about a better project monitoring system, where the possible delays could be identified earlier and the problems related to them decreased *(David et al., 2013)*.

Small actors have been excluded from the Brazilian renewable auctions. Although the costs of prequalifying as a bidder by for example environmental licences are not considered to be too high for small actors, the financial guarantees required often prevent small or local actors from participating in the auctions. *(Held et al., 2014)* The auction design as a whole is also very complex compared internationally *(Elizondo Azuela et al., 2014)*, which does not increase the attractiveness of the auctions for small actors. As the competition has been so high and prices extremely low, small actors have not had the same possibilities of clever and low-bid bidding strategies as large, international actors. Therefore, the small actors do not appear in the Brazilian auctions. *(Held et al., 2014)*

All in all, Brazil is an exception among the other analysed countries in this thesis in many senses of renewable energy auctions. The need for the auctions resulted from severe energy shortages caused by a dry period in a hydro power dominated country and only later was started to apply to promote renewable energy. The auctions have attracted many bidders and proven to be very competitive. Also the Brazilian energy mix has become more diverse, which was proven in a dry period recently, when the energy shortage was much less severe than in the previous dry period. However, the competition in the auctions has been so high that the prices have been driven down, even to levels with unsure financial feasibility. This has led to a new concern of auctioned capacity not being realised and again leading to capacity adequacy problems. At the moment, however, Brazil is continuing auctions for both conventional and renewable energy. To conclude the most relevant observations from the

Brazilian renewable auctions from the point of view of small actors, a summary is presented in *table 8*.

Table 8 Summary of the Brazilian auction experiences from the point of view of small actors.

Technologies	hydro (small and large), biomass, onshore wind
Small actors	no small actors at all
Experiences	realisation and delay problems, network connection problems
Main problems in small actor participation	no small actors in the markets and not promoted to get new small actors, high competition level, strategic underbidding, dominance of one company, complex design, high financial guarantees
Recommendations for small actors	none

4.6 Overview of the auctioned technologies and actor variety in the analysed countries

To clarify the auction experiences in the five discussed countries and to give an overview of them, the technologies auctioned in each country are presented in *figure 1*. Additionally, the figure presents in which countries and technologies small actors have been participating and successful and where only large actors have been competing. The auctions have already been applied to a wide range of renewable energy technologies in the discussed countries, but there are only four of them in which small actors have been participating and successful: solar thermal, solar photovoltaic, onshore wind and biomass. The next chapter analyses more detailed the features of the discussed auctions and the market structures of the countries and concludes the best practices for small actor participation promotion identified in the analysis.

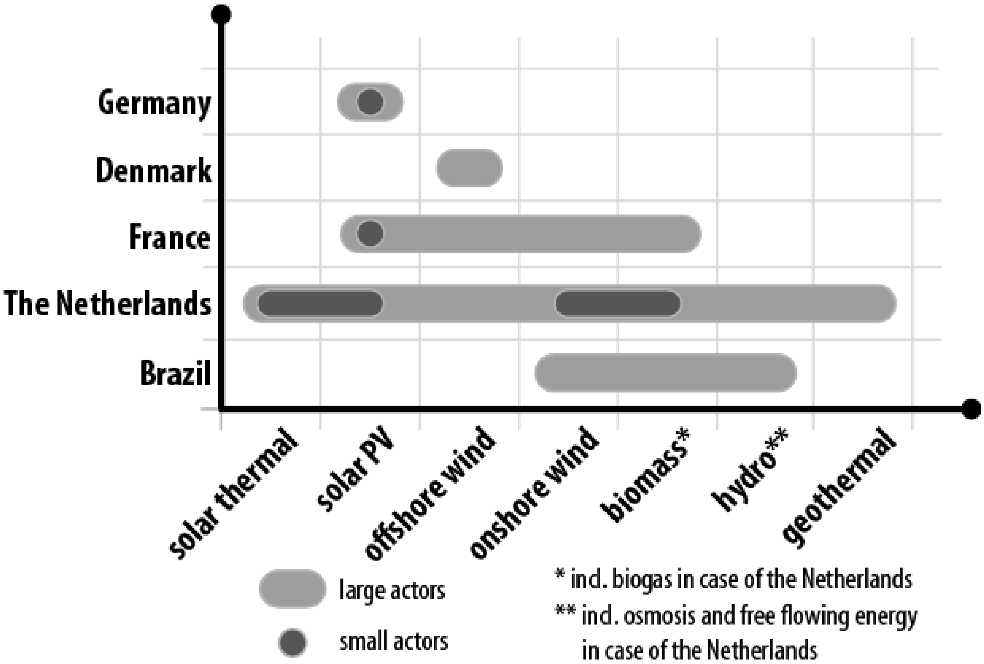

Figure 1 Compared countries, auctioned technologies and actor diversity in the auctions. The size of the grey dots and ellipses does not represent the number of actors in the corresponding actor group.

5 Best practice recommendations for small actors in renewable energy auctions

As the literature review of the five analysed countries reveals, the auction design in different countries can vary a lot. Because of different designs and energy market structures in the five countries, also small actor participation in the auctions vary: some countries have implemented auctions specially to facilitate small actor participation and also succeeded with that design, whereas some countries have auctions without any small actors participating at all. In order to identify the factors enabling small actor participation in the auctions, a qualitative comparison between the countries is conducted. First, a short summary of each country in sense of small actors in the auctions is presented to have a better overview of the main points of the literature review. Then, the elements and features of each country's auctions are compared in detail. Lastly, the identified features are compared with the energy market structures of each country.

Germany has traditionally had a large actor variety in the energy sector and with implementation of the auctions it also wanted to preserve it. The auctions were designed to be as simple as possible not to scare small actors. Also some features were intentionally designed in favour of small actors: the flexible financial guarantee and penalty payment scheme lessens the auction risks if the actor already has a building plan, thus offering for example for small actors the possibility to smaller initial costs and financial risks. Also in case of same bid prices, the smaller volumes are preferred, which often gives advantages to small actors as they typically create smaller projects. The rules regarding owner and location changes prevent large actors to some extent to use their larger portfolios and therefore equalise a bit small and large actors' possibilities in the auctions. The design seems to have worked – in the auction rounds held, there has been a large variety of actors participating, from private persons to large companies. One factor affecting the actor diversity is also very likely the energy market structure in Germany, where also small actors have been participating in energy generation and it is thus easier to follow the tradition. The competition in the auctions has been high and the winning prices thus rather low. Probably because of that, not that many small actors have been successful in those rounds. However, some smaller actors have been in the winner category, thus indicating that the German auction design combined with its market structure does allow small actors to successfully participate in the auctions.

Denmark has auctions only for offshore wind. This technology is by nature characterised by large projects realised almost always by large actors. That is the case also in Danish offshore wind auctions: only large actors bid for the projects. However, as wind energy is a really important energy source for Denmark and to be able to increase its capacity, it is also important that it is generally accepted by the people. Therefore, a scheme involving small actors in form of local citizens indirectly in the auctions is in use in Denmark. As the project realiser has to offer 20 % share of the project to buy to local citizens in case of nearshore auctions, the citizens can also benefit from the projects and thus more likely also regard the projects more positively. This can, however, not be considered as a true way of including small actors in the auctions but rather as a creative and apparently functioning solution to bring large technology projects closer to people.

France has a wide experience with renewable energy auctions. However, only the most recent solar photovoltaic auctions have attracted small actors and also allowed them to bid successfully. The medium-scale PV auctions are mainly intended for small actors, that is private building owners who are willing to install rooftop solar panels. The auction process is rather simple, the bids are submitted through an online system and new rounds are organised regularly and predictably, which seem to suit well small actors' needs. The French solar PV auctions have, however, clearly proven that the simpler the auction design is the better it is for small actors. The required CO_2 assessment in the first rounds decreased the competition level significantly, thus showing that small actors do not bear any additional or complicated procedures to be conducted prior to the auction. If some special criteria are, however, required, the rules regarding it should be so clear and simple that also for example private persons not specialised in energy technology can understand them and perform the process accordingly.

The Netherlands shows a positive example of small actor participation in the auctions. Even though the auctions are designed for short-term renewable implementation with as low costs as possible and competition has been very high in the past rounds, small actors have been actively participating and also been able to win the auctions. The auction design is rather simple, as no extensive prequalification criteria are required and ascending clock as the auction mechanism is quite easy to understand. As the rounds are organised yearly and the bidder only has to submit their bid when the price cap of the round is suitable for them, the bidding strategy does not necessarily have to be a sophisticated one. The technology-specific price caps are implemented to avoid windfall profits, but can as well be seen to serve as a possibility to receive a bit higher prices for some technologies and thus probably also to assist small actor participation. The penalty payments system also reduces risk for small projects and thus often for small actors, as a penalty due to delay or cancellation is only to be paid when the project budget is over a defined limit.

The case of Brazilian renewable energy auctions is the most unsuccessful one of the analysed countries in terms of small actor participation, as there are no small actors in the auctions or energy markets generally. One reason for that is very likely the market structure, where Electrobras with its subsidiaries still dominates and companies trying to compete against it have to have very low prices. The auction design itself does not facilitate small actor participation either: the system is complex, the financial guarantees required are probably too high and the high competition level has led to really low, even unfeasible prices. Therefore, large domestic and international companies seize the auctions. Additionally, as the transmission system extensions are often delayed and some distribution companies are in a poor economic condition, adding risk to energy projects, the Brazilian energy market and auctions are even less attractive for small actors.

An extensive comparison between the five analysed countries is conducted in a table in *Appendix 1*. The important observations concluded from the table are analysed in the following paragraphs. As the comparison is between five countries, there are some aspects that might not appear in this comparison but might still be noteworthy. Furthermore, in some categories no relation between the category and small actor participation is found in this comparison. This must not mean that there would not be any relation generally, but no relation exists in the comparison of the analysed countries.

Generally, if small actors are taken into account when designing the auctions, it seems that the auction also manages to attract them and allow them to be successful, at least to some degree. However, a special design according to small actors' needs seems not to be necessary in all cases. Moreover, exception rules for small actors for example in terms of evaluation criteria or different auction categories have not been in use in any of the analysed countries and thus it can be concluded that they are not always necessary either. Bidder concentration rules might set smaller actors in a better position if for example one bidder is not allowed to win more than a specific percentage of the auctioned amount. However, these kinds of rules are not applied in the analysed countries, so that, either, seems not always to be necessary. There were some rules applied for project sizes or minimum number of bidders for the auction to be organised, but the implementation of those rules does not seem to have any correlation with small actor successfulness. Solar photovoltaic seems to be the most suitable technology to be installed and operated by small actors. In the countries where the auctions are organised only for solar PV, also small actors are being successful in the auctions. In these countries, however, the auctions are also designed to suit small actors. With technology-neutral auctions, solar PV technology has the most successful small actors. One technology has clearly shown no to be fitting small actors: offshore wind. However, the narrow actor diversity in this case is not only a feature of offshore wind auctions but rather a general nature of offshore wind projects being large and capital-intensive.

One rule seems to apply to many design elements: the simpler the design, the better it is for small actors. It also applies for the general ensemble of the auctions, and it is not always enough to design only the separate details simply but to consider also the simplicity of the design as a whole. If the bids are to be submitted online, it simplifies the physical procedure and thus facilitates the auction attractiveness to small actors. However, an online process is not necessary in order to include small actors. The auction mechanism has also an influence on the small actor participation. The same rule applies to it, the simpler the mechanism is, the easier it is for small actors to participate. When the mechanism is understandable, it attracts small actors because they do not have to use as much resources on familiarising with the system itself. For example, sealed-bid and ascending clock auctions have in the analysed countries proven to be suitable for small actors. In both mechanisms, when presented in a simplified manner, the bidder only has to submit the bid and wait for the results. On the contrary, for example a hybrid mechanism that is in use in Brazil, requires the bidder to be more active in the bidding phase and submit several bid prices after another. That kind of design seems to demand more bidding strategy knowledge and acts therefore as a hurdle for small actors.

The preparation for the auctions is optimal for small bidders if it is kept to minimum. Rather frequent rounds seem to facilitate small actor participation, too, though it is also a feature helping all kinds of actors generally. The prequalification criteria should be kept only in few criteria and not too investment-intensive, as small actors rarely have high financial liquidity.

As some criteria is almost in every auction case necessary to enable a good auction outcome, also small actors have to bear some preparation work and costs. It seems that the most suitable prequalification criteria to be rather easily fulfilled also by small actors are for example environmental or building permits or decision on location. These criteria can be summarised as criteria the actor would anyway have to complete at some stage of the project realisation in case the project is realised, but do not require high investments. Also some well-scaled and especially flexible financial guarantees seem to be bearable for small actors as long as they are not too high. On the contrary, high financial guarantees or some additional work, for example assessments that a project developer normally does not have to conduct when installing a project, seem to be hindering small actors' interest in the auctions.

The decision between technology banding or technology-neutral auctions did not have much effect on small actor participation in this comparison. There were successful small actors in auctions banded only for solar photovoltaic but also in technology-neutral auction. In the technology-neutral auctions, however, every technology had their own price categories and thus also for example small actor friendly solar PV technology could receive high enough support levels and probably thus increase the possibilities of small actors to success. Thus, it can be concluded, that banding might help small actors but the dependence is not totally clear. A clear relation cannot either be found between small actor participation and the existence of other support methods at the same time for the same markets. However, if there are other support methods, they might create an unintended minimum price for the bids as it would make no sense for the bidder to receive a lower price after a laborious auction process than what the actor could receive by some other, simpler method. This is especially true for small actors, as they do not bear much extra work and they prefer the simpler ways for receiving support. Thus, in not only on small actors' perspective, auctions should be the only support method for a target group of technologies or actors.

The relation between small actor interest and auction evaluation criteria seems to be very unambiguous: only price as an evaluation criterion suits small actors the best. If there are some extra evaluation criteria, it complicates the auction process and its intelligibility and lessens its attractiveness from the point of view of small actors. However, there were no countries in this comparison, which would have had some main evaluation criteria especially designed to increase small actor winning possibilities (except Germany's small project preferring rule in case of same bid prices, which is only a minor scheme in the evaluation). Therefore, those kinds of rules cannot be commented based on this comparison. The penalties applied on winning projects in case of project delay or failure pose always an additional risk to the auction participants. As small actors can tolerate less risks than larger actors, the penalties should be kept in minimum in order to attract small actors. International experiences show, however, that if no penalties are applied, the project realisation rate tends to decrease. Therefore, some penalties are almost always necessary, and thus also to be tolerated by small actors. Indeed, small actors seem to cope with the risk of penalties in case the penalties are not too high or even better, flexible, thus mitigating the penalty risk.

Quite surprisingly and against many assumptions, small actors have been able to participate and be successful also in rather competitive auctions in this comparison. In fact, in both Germany and the Netherlands the competition level has been very high and especially in the latter, the main goal of competitiveness and low prices would make one assume no or not many successful small actors. However, these countries are exactly the ones among the analysed five countries where small actors seem to be able to compete best in the auctions against larger actors. The auction winning prices have also been in both countries in rather low levels, though not yet unfeasible. One reason for the surprising result might be that the competition in both of these auctions seems to be healthy and collusion and strategic bidding have been avoided, when not totally, then at least to an extent where it does not distort the auction results. Therefore, the prices have been in low but still reasonable and economically feasible levels. This has apparently given possibilities for the best and least-cost small actors also to successfully participate in these auctions.

The country comparison in terms of important features for small actor participation shows some clear relations and good designs to enable small actors to participate in the auctions, but also practices that hinder small actor participation and elements with no relation to it. However, an auction design functioning in one country and attracting many small actors is not necessarily as successful in some other country, especially if the countries and their energy market structures are very different. Therefore, it is always important to recognise the context of an auction. To better understand the above identified factors, they are compared and analysed with the renewable energy market structures of each country of this thesis.

As stated many times before, Germany has a history of a large actor variety in renewable energy markets. In fact, Germany has the largest number of companies acting in energy markets compared to all other European countries, when companies in the fields of electricity, district heating and gas are compared. Moreover, two thirds of these companies are small and medium enterprises. *(BDEW, 2012)* Because small actors are a significant part of the German energy markets, it is logical that the auctions were also designed to suit them. Probably because of a long tradition with small actors in energy markets, no exceptions were designed for them in the auctions, and the small actors seem to cope with that as they are used to participate in the energy markets. The pilot technology choice of solar PV seems also logical, not only because of the before justified reason of quick implementation but also because Germany already has a lot of solar energy and it is also one of the most promoted technologies for German Energy Transition. Thus, combining these factors, small actor tradition and a technology important for the country, the successfulness of the scheme with small actors is also rather likely. The high competition level seems also expectable as there are so many actors in the German energy markets. Probably one reason for small actor successfulness in the competitive auctions, in addition to the reasons identified above in this thesis, is their routine in acting in the energy markets and therefore their experience and adaptability, also in price reductions.

In Denmark, there are two large companies, who own a significant share of the Danish electricity production capacity. There are, however, also smaller actors for example in small-scale combined heat and power production and small-scale wind power production. *(IEA, 2011)* As the auctions are only organised for offshore wind power and also not planned for other renewable technologies, only market structure in the offshore wind sector is relevant in case of Denmark. Offshore wind market in Denmark has only large actors, as stated before. As the project size and complexity already practically always requires large companies in wind energy projects, the auction design itself cannot be blamed for the lack of small actors in the offshore wind auctions, and it is therefore not meaningful to analyse the before identified, small actor participation enhancing factors in this context.

The French power production sector is strongly dominated by one company, EDF, which was the state power producer company before market liberalisation and is still controlled by the state. It owns approximately 80 % of the power production capacity. The next 15 % of the capacity belong to two large companies, and only 5 % to small or medium sized power producers. *(Deloitte, 2015a)* Because of this market structure, which was before even more dominated by EDF, it is rather obvious that the first two auction systems were not designed for small actors or that there were none of them participating. In the new medium-scale solar PV auctions, the auction design is made especially for small actors as they are the target group of that scheme, and therefore in this submarket no exception or bidder concentration rules are needed for small actor enhancement. Here it also becomes clear that even when the renewable energy market itself is not very small actor friendly, in this case because of the dominance of few large companies, it is possible to create a submarket for a specific technology, where also small actors are able to compete. Also in this case the small actor friendly technology is solar photovoltaic.

The Netherlands has a moderately concentrated power market in terms of market actors. There are four large companies, which own altogether 55 % of the installed capacity. However, the rest of the capacity owned and power produced is divided between as many as about 800 generator enterprises. *(Deloitte, 2015b; European Commission, 2014c)* Although the majority of the Dutch energy production is owned by large companies, the renewable energy auctions have attracted mainly only small or medium sized actors. One reason for this might be the fossil fuel intensive power production in the Netherlands, where the renewable energy business is still rather small, maybe does not thus attract as many large actors and is therefore comparatively easy for small actors to attend. As there are generally many actors in the Dutch energy markets, this might be one reason for the high competition level also in the auctions. Furthermore, because the auctions are basically technology-neutral, all the energy market actors do compete against each other, increasing the competition level. However, the competition seems to be healthy, which also might be caused by the large actor number in the Dutch energy markets: there are so many actors that for example collusion might be hard to practice in larger or disturbing levels.

As mentioned before, the energy markets of Brazil are characterised by large domestic and international companies and the dominance of the former state power company Electrobras and its subsidiaries. The power production market does not have small actors, so it is obvious that the auctions are by no means designed for small actors. Brazil has also only very little, practically an insignificant part of its energy production mix, produced by solar power, mostly because of the high costs of the technology *(Corrêa da Silva et al., 2016)*. As solar photovoltaic power is identified as a suitable technology also for small actors, one reason for the inexistence of small actors in the Brazilian energy markets might also be the lack of the fitting renewable energy category generally in the energy markets and also in the auctions. As a conclusion of the Brazilian case, if small actors are not important in the markets or for the decision-makers, they do not have many possibilities in the markets.

To conclude this chapter, a table with the most important and relevant factors of the country comparison are summed up in *table 9*.

Table 9 Concluding relevant observations of the country comparison.

Factor	Impact on small actors	Market structure impact on the factor
Suitable technologies	the most suitable: solar PV, the most unsuitable: offshore wind	solar PV also auctioned if important for the country's energy mix/expansion; possible to create solar submarket suitable for small actors
Auction mechanism	the simpler, the better (e.g. sealed bid or ascending clock)	none identified
Frequency	good, but helps also large actors	none identified
Online auction	good but not necessary	none identified
Prequalification criteria	not too costly but necessary licenses OK	none identified
Financial guarantees	the smaller, the better; flexibility helps	none identified
Bidder concentration rules	might help but not necessary	if small actors the only target group, no rules required
Banding	might help	none identified
Evaluation method	price only	none identified
Penalties	the smaller, the better; flexibility helps	none identified
Competition	when healthy, then high competition OK	many actors -> no collusion; if small actors already before in the markets, experience helps also in competition
Winning prices	rather low prices still OK when not strategically/unfeasibly low	many actors -> no collusion -> acceptable prices
Simplicity	the simpler, the better	none identified
Designed for small actors	attracts small actors but not necessary	only happened in countries with already small actors in renewable energy markets
Exceptions for small actors	not necessary	when the market already has a tradition of small actors, exceptions probably not needed

6 Experiences in auctions and small actors in other industrial sectors

Renewable energy is not the only sector where auctions have been organised to award concession rights. Also in some other sectors, where the resources are limited, it is considered efficient to allocate the scarce resources by auctions. Moreover, as the auction system is by nature promoting efficiency, which is not the advantage of small actors in many cases, auctioneers in many other sectors have also had to consider the problem with small actors: should the auction efficiency be the sole objective or is actor variety still in some cases more important and should thus be promoted by some special means? This chapter gives a short overview of a few auctions in other sectors in terms of small actors and draws conclusions that could also be applied to small actors in renewable energy auctions.

In the USA, spectrum auctions have been used to allocate licences for wireless communication since 1994. Until 2011, 70 auctions had been organised. *(Cramton et al., 2011)* Before the spectrum auctions, the licenses were awarded by comparative hearings or lotteries, and the current auctions are stated to be clearly the most efficient method for allocating the licenses and that the licenses are given to the actors who the most value them. In addition, the U.S. Treasury receives the bid prices as revenues, as the spectrum auctions are ordinary and not reverse auctions as renewable energy auctions. *(Cramton, 2002)* In these U.S. spectrum auctions, the auctioneer is obliged to design the auction so that also small businesses can participate. The obligation was justified by equity and efficiency reasons: the equity for all sizes of businesses should be offered by auction design because small actors often naturally have disadvantages, and efficiency could be brought by small actors by forcing also larger actors to provide better services with smaller prices and small actors were also considered to be more innovative. There have been a few ways to enhance the small actor participation in the U.S. spectrum auctions. On some auction rounds, some frequency blocks are assigned only for small bidders so that large companies cannot bid in those categories. This method is called small business set-asides method. Another method is a bidding credit system, where the government offers subsidies for a fixed percentage of the small bidders' winning bids and the small bidders thus do not have to pay the whole bid price. For both of these systems, the businesses are classified as small bidders by the annual gross revenue and assets of the company. For some later rounds, an additional small actor promoting method has been applied: large frequency blocks have been divided into several smaller ones, because small businesses can better operate small blocks instead of large ones. *(Musick, 2005)*

The special rules for small actors have not, however, been trouble-free. When the small businesses are preferred in the auctions with some exception rules, the licenses are not necessarily auctioned to those valuing them the most, and the income received from the auctioned licenses is decreased. Furthermore, in some cases, the small businesses that have won the auctions have not been able the start to operate the wireless network or have started with delay, as larger frequency blocks are hard for small businesses to properly operate. Therefore, the network users, companies or private users, have had less access to the networks and in some cases they also have paid more for the services. Sometimes it has taken years to auction the license for a frequency block again after a failure to operate. Additionally, many of the small bidders have sold the licenses auctions to larger businesses after the auction, when they have realised that they do not have the financial resources to pay for the license and operate it. In theory, there is a penalty to be paid if the license is sold in the first five years, but many small businesses have been exempted from the penalty payment. This has led to lower small actor share in the license ownership distribution as planned. Because of these failures, and although there have also been small bidders dealing well with the license operation, the small actor facilitating scheme in case of U.S. spectrum auctions has not been very successful. *(Musick, 2005)*

Japan has used auctions for civil engineering works since 2005. In these auctions, Japan has been using a similar method as the USA for the spectrum auctions: set-asides for small and medium sized actors. About 60 % of the auction budget has been earmarked to be allocated only for small or medium sized businesses in the auctions. In Japan, the small and medium sized enterprises are defined by employer number and enterprise capital. *(Nakabayashi, 2013)*

In California, highway construction and repair contracts are auctioned. The goal is to allocate 25 % of the money budgeted for highway procurement to small businesses. To achieve the goal, bid preferences are used for small actor participation enhancement. A bid preference means that when a bidder categorised as small business bids a defined amount or percentage higher than the theoretical winner bidders, the small business is awarded instead of a larger, lower bidding actor, against the cost efficiency target of an auction. In Californian highway auctions, small businesses are defined so that they have under 100 employees and less than ten million dollars of annual revenues. Additionally, the company has to be located in California and cannot be a subsidiary of a larger company. The bid preference amount for small bidders is either 5 % of the lowest bid of a large company or 50 000 dollars, whichever is smaller. *(Marion, 2007; Krasnokutskaya & Seim, 2011)*

The experiences from the conducted Californian highway auction rounds show, as there are also rounds without the bid preferences for small actors organised, that the rounds with bid preferences do attract more small businesses to participate. Also the percentage of successful small bidders is higher in the rounds with bid preferences. The experience show, therefore, that the program has been able to enhance small actor participation. The goal of 25 % of the procurement budget allocated to small businesses is, however, not entirely reached. Moreover, because of the small bidder preferences, the cost efficiency of the auctions is reduced. *(Marion, 2007; Krasnokutskaya & Seim, 2011)*

Also in Texas, highway construction contracts are auctioned. These auctions do not have direct goals of small businesses as successful bidders but in some of the auction rounds a defined percentage of the project has to be conducted by small businesses as subcontractors of the actual bidder. In this case, it is not enough that the subcontractor company is small but also has to be owned by people from minority groups or by women. The small business percentage required as subcontractors is at the most 15 % and varies between the auction rounds. Generally, the rule does not apply for small projects auctioned. The scheme seems to have functioned not only in promoting small businesses as subcontractors but also in cost efficiency: in the rounds with obligations for small business percentage in subcontractors the bids have not been significantly more expensive than in the rounds without the obligations. *(de Silva et al., 2012)*

The few examples from other sectors' auctions used four different methods for small actor participation enhancement: set-asides, bidding credits, bid preferences and obligatory percentage of small businesses as subcontractors. The three first of them fall in the category of making exception for small actors in order to promote them in the auctions, and the last one uses obligations to indirectly involve small actors in projects auctioned. All of those methods have one common problem if they would be applied to renewable energy auctions: small actor would have to be defined. All of the example auctions of this chapter have defined small actors by the employer number and/or financial details of the bidder company. In case of renewable energy auctions this could be, however, more complicated, as stated already in the chapter 3.1 Definition of a small actor. As many typical small actors in the renewable energy context are for example private persons or local cooperatives, who only initiate one or very few projects, the financial details of that actor could not be defined. The definition could, of course, be conducted by other, in the chapter 3.1 suggested means, but the according problems might arise. However, if those problems are overcome and a suitable definition of a small actor for a specific market found, all of those four options might be considered as small actor promoting methods in renewable energy auctions. No discussed auctions from other sectors had any suggestions for general auction design element best practices to promote small actors without making special exceptions for small actors. Therefore, only the exception schemes and their possible implementation in renewable energy auctions are analysed in the following paragraphs.

Set-asides are a relatively simple and understandable method to ensure small actor participation in the auctions, and would most likely be that in renewable energy auctions, too. Some percentage of the auctioned capacity could be earmarked only for small actors even if their bids were higher than some of the large bidders' bids. Before the implementation, it would be important to ensure that there is enough competition for the small business earmarked percentage of the capacity. However, similar problems might arise as what are described in the USA spectrum auction context. The cost efficiency of the auctions would in most of the cases decrease, as higher bids would be preferred. The problem of not realised projects would probably be not that acute as in the frequency auction, as the frequencies are auctioned as pre-defined blocks, which might sometimes be too large for small actors, but in the most cases of renewable energy auctions the project size is rather freely to be decided by the bidder. Therefore, small bidders in renewable energy auctions would most likely initiate projects of a suitable size for them to operate. Selling the project after the auction to a larger bidder could also happen in renewable energy auctions. Therefore, a high enough penalty for selling the project should be implemented and exempts to that penalty given only with well justified reasons. However, set-aside rules do affect the market situation artificially and might distort the market and competition, especially in a longer timeframe.

Bidding credits could not be implemented in the same form in renewable energy auctions as how they are in use in spectrum auctions, because renewable energy auctions are reverse auctions. They could probably be implemented in renewable energy auctions so that the bidder, in case of being awarded as winner, would receive higher price than the bid and/or winner price. The extra price would, however, have to be really carefully scaled to avoid windfall profits in case of too high extra price. If designed this way, the scheme would actually resemble a lot the bid preference scheme. In the bid preference scheme, small bidders' bids would be considered a defined amount lower than what they actually are when awarding the bids. From a bidder strategy point of view, this would lead to same decisions of a bidder when bidding as in the proposed bidding credit system in renewable energy auctions. The scheme of bidding credits or bid preferences would most likely attract more small actors than an auction design without such schemes, as the chance of winning would be higher. All the problems of the previous paragraph could, of course, appear also when implementing bidding credits or bid preferences. They would most likely also have an impact on the competition. It is, however, impossible to say if the impact would be positive with more small bidders or negative with fewer large bidders.

The scheme with a specific percentage of small businesses as subcontractors could also probably be implemented in renewable energy auctions. This would, however, not increase the small actor participation in actual energy markets but in for example power plant parts producing facilities, transportation companies and so on. In highway construction contracts the situation is different, as the contact is only made for the construction of a few months' duration, and for that also subcontractors work in the actual, targeted field of road constructing. In renewable energy contacts the main weight is in addition to the power plant building also on the operation of the plant. As the scope of this thesis is to analyse small actors particularly in the renewable energy production sector, this scheme does not seem very relevant to analyse further in this context. It could, however, be an efficient scheme to promote small actors in the renewable energy sector in a larger perspective.

As the all examples of small actor promoting schemes in this chapter include exceptions created for small actors, this chapter supplements well the comparison of the five countries with renewable energy auctions analysed in the previous chapters. None of those countries had implemented any methods for small actor participation enhancement which would give some exception for small actors, when they participate in the auctions. As can be concluded from this chapter's short overview, exception rules for small actors are in use in some auctions and can be functioning. However, when implementing the exception rules, the definition of a small actor has to be considered carefully and the actual scheme has to be well thought-through to fit the specific market situation. Monitoring of the successfulness of the scheme also has to be conducted thoroughly to avoid misuse of the special rules and the small actor status.

7 Conclusions

Auctions are becoming all the time more popular as the support method for renewable energy. The advantage of this method over the other traditional support methods is its ability to reduce the costs of renewable support to the society. To ensure that the auctions function in a proper and planned manner, they have to be designed carefully to suit the specific market situation and the goals of a country.

As auctions are a competitive procedure and the price of the bids usually defines, at least partially, the winners, the bidders with lowest prices have the largest advantages in the auctions and possibilities to win. Typically, large actors can use their wide portfolios, create larger projects and take the advantage of economies-of scale effect to lower their bid prices. On the contrary, small actors normally create smaller, fewer and more specific kind of projects and cannot thus benefit from those features. Therefore, if a country wants to have also small actors participating and winning in the renewable energy auctions, in many cases it has to be taken into account already when designing the auctions. The decision if small actors are to be promoted in the auctions is often a compromise between cost efficiency and actor diversity in the auctions or renewable energy markets generally. Actor diversity and many small actors in the auctions bring a variety of benefits: higher social acceptability, deployment of the widest possible renewable energy mix and project distribution, lower electricity grid congestion issues and decreased collusion by more actors competing in the auctions. However, if these factors are preferred over an absolute cost efficiency, the basic rule of the auctions of reducing support costs to the minimum is violated. Therefore, it is important for the decision-makers to consider the advantages and disadvantages of both options carefully when implementing the auctions.

The optimal design for small actor participation enhancement is not an easy task and there is no design that would fit all the market situations and countries. Therefore, this thesis analysed five countries, which had implemented renewable energy auctions, and compared their experiences with small actors in the auctions. The comparison identified some common features in those countries and based on those, conclusions can be drawn for small actor promoting design of an auction. Solar photovoltaic seems to be the most suitable technology for small actors in the auctions. Therefore, if a country would like to have more small actors in the renewable energy auctions, it could be recommended to start to experiment a proper design with auctions for solar PV. Generally, the auction design is to be as simple as possible to attract small actors, as they cannot bear extra hurdles, risks and costs as easily as larger actors can. The auction mechanism should be easily understandable and not require complicated bidding strategies. For example, sealed bid and ascending clock auctions have been functioning as a suitable auction mechanism for small actors. The prequalification criteria should be well scaled and not require too much work and costs prior to the auction. Small actors seem to handle as prequalification criteria for example getting some obligatory licenses they would anyway have to have when realising a project. Also small and in the best case flexible financial guarantees are tolerated by small actors, as long as a large amount of money does not have to be deposited before the auction. The evaluation criteria should also be as understandable as possible not to deter small actors. Price-only evaluation seems to be the best option among the compared countries when promoting small actors in the auctions.

However, prior evaluation criteria preferring especially small actors was not in use in the analysed countries, so no conclusions can be drawn of the functioning of that kind of criteria. Penalties are always an additional risk to the bidders, and as the risks are proportionally larger for smaller actors, the penalties should be kept, like the financial guarantees, small and flexible.

One rather surprising conclusion resulted from the country comparison: against many assumptions, small actors have been participating and successful also in auctions with high competition level. This might indicate that small actors are, after all, not as disadvantaged in the renewable energy auctions as sometimes thought. The competition, however, has been in these auctions healthy and not collusive. Thus, the winning prices have also stayed in proper, feasible levels enabling more possibilities for the most cost-efficient small actors. Therefore, it is important to ensure healthy competition, where no collusion, underbidding or strategic bidding happen, in order to attract small actors and give them a real possibility to win.

In the analysed countries, there were no exception rules in use for small actors. However, the short overview of auctions in some other sectors provided experiences for this aspect, as well. The identified exception rules for small actors were set-asides, bidding credits, bid preferences and obligatory percentages of small actors as subcontractors. The first three of the rules could also be working in renewable energy auctions enhancing the small actors in energy production. The rules would give small actors a special status, thus requiring a strict definition of a small actor. They would, most likely, attract small actors in the auctions and offer them better possibilities to bid successfully. However, the costs of the support scheme would most likely increase. One could also argue that free competition is restricted when an actor group receives a special treatment. However, in some extreme cases where it is otherwise really hard for small actors to participate or to be successful in the renewable energy auctions, exception rules could be a possibility to mitigate the problems and design the auctions better suitable for small actors. When exception rules are applied, they have to be designed carefully to avoid misuse and other possible problems.

As can be seen, there are several elements, which with a specific design could mitigate problems for small actors in the auctions and facilitate their participation and successfulness. The auction design as a whole is a challenging task with trade-offs between different benefits and disadvantages of the specific design of each design element. Therefore, the small actor participation enhancement is only one of the possible goals of an auction, and the design cannot thus be solely designed aiming only to this target. The features identified in this thesis for small actor promotion are, however, possible to implement also when a variety of other goals are set for the auctions. The trade-offs have to be considered carefully and in many cases also experimented empirically by pilot auctions to iterate the best possible auction design to facilitate the goals set for the auctions, the current market situation and the renewable energy targets of a country.

The recommendations of this thesis should, however, be considered properly with the current market situation. As only five countries were analysed, this thesis has some limitations in its applicability. The five countries give only a narrow review of the diverse practices and markets in the countries with renewable energy auctions in the world. The analysis is by no means complete and comprehensive, but only a first iteration of a possible wider research of more empirical examples and their experiences. There are many design elements, where no relation to small actor participation was found in this thesis, but this does not necessarily mean that there would not be any relation between them in any markets. Also some relations identified might be different when applied to completely different market structure contexts. Moreover, the experiences in some of the analysed countries are not yet long enough to be able to draw final conclusions on the functionality of the specific designs.

Therefore, there are many directions the research could be continued in possible future works. When the analysis is extended to more countries, the perspective can be widened and applied as more comprehensive. To be able to gather more reliable information for some countries, several years would have to be waited in order to complete more auction rounds and give the projects time to be in operation. This way the successfulness of an auction design can be judged more reliably. One interesting direction of further research would also be to involve the small actors themselves in the study and by interviewing gather their opinions and experiences. This information could be applied to a research conducted from the actors' point of view, not from the regulator or decision-maker's point of view of auction design.

All in all, the renewable energy auctions are a hot topic in the near future in climate change mitigation in the energy production sector. It remains to be seen, how effective they prove to be in renewable energy deployment and cost reductions of renewable energy support. The involvement of small actors in the auctions arises often when designing the auctions and it has to be decided in every country individually, if that will also be one goal of the auctions.

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Appendices

Appendix 1. Country comparison: Different factors' impact on small actors

	Important RE	RE percentage 2014	RE goal	Market structure	Political stability
Germany	solar, wind, (hydro biomass, geothermal)	32,5 % of electricity demand	2025: 40-45 %, 2035: 55-60 %, 2050: 80 % of electricity demand	large actor diversity, many players	good, RE-committed country
Denmark	wind, biomass, (solar, hydro, biogas)	53,4 % of electricity demand, 28,5 % of energy demand	2020: 35 % of energy & 50 % wind of electricity demand, 2035: 100 % of electricity & heat demand, 2050: 100 % of energy demand	only large domestic & international actors in offshore wind markets	OK, at the moment RE friendly government
France EOLE					OK, though the system changed often
France PPI					OK, though the system changed often
France PV	hydro, wind, solar, biomass	19,5 % of electricity demand	2020: 23 % of energy demand & 27 % of electricity demand, 2030: 32 % & 40 % respectively	one company (EDF) dominates, but also small actors	OK, though the system changed often
The NL SDE					
The NL SDE+	"all", especially the cheapest ones	2011: 4,3 % of energy demand, 2013: 9 % of installed capacity	2020: 14 % of energy demand	4 companies dominate (55 %), altogether ca. 800 generator companies	many changes, current policy only until 2020
Brazil	hydro, wind, biomass	hydro 63 % of electricity demand		dominance of Electrobras & its subsidiaries, large companies	RE policy OK, otherwise sometimes unstable
Impact on small actors	no relation	no relation	no relation	when already small actors in the market, easier for the auctions to attract them	stability good, but when not too unstable, small instability still OK

	Auctioned technologies	Previous support system	Mechanism	Product	Quantity	Frequency
Germany	ground-mounted solar PV (2017-> all RE technologies)	generous feed-in tariff	sealed-bid, pay-as-bid (2nd & 3rd round uniform price)	capacity	100-200 MW /round	3 x/year
Denmark	offshore wind	feed-in tariff	single-item, pay-as-bid, sometimes negotiations (nearshore multi-item)	capacity	200-600 MW /project, nearshore 305 MW	when needed
France EOLE	wind	none		capacity	altogether 361 MW (51 projects)	
France PPI	onshore & offshore wind, biomass, solar	EOLE	pay-as-bid	capacity	depends on the round	when needed
France PV	solar PV	PPI	pay-as-bid	capacity	30-120 MW	2-6 x/year
The NL SDE	offshore wind	feed-in tariff			950 MW	only once
The NL SDE+	all + renewable heat & biogas	SDE	ascending clock with 5 rounds	volume	until the yearly budget exhausted	1 x/year with 5 in-auction rounds
Brazil	hydro (small and large), wind, biomass	feed-in tariff	hybrid: 1st stage descending clock, 2nd stage sealed-bid pay-as-bid	average MW	amount estimated by distribution companies	A-5 & A-3 yearly, others when needed
Impact on small actors	solar PV good (when only solar PV auctions, there are many small actors, when technology-neutral auctions, the most small actors in solar PV), offshore wind not suitable	no relation	The simpler, the better (e.g. sealed-bid pay-as-bid & uniform price, ascending clock)	no relation	no relation	often good

	Predictability / regularity	Contract duration	Online	Prequalification criteria	Bidder concentra-tion rules	Price limits
Germany	very good	20 years	no	location, decision on building plan/decision on publication/approved building plan, 1st deposit 4/2 €/kWh, 2nd deposit 50/25 €/kWh	project size min. 100 kW, max 10 MW	price cap 1st round 11,49 c/kWh, next rounds lower
Denmark	not regular but announced well ahead of time	50 000 full load hours (~12-15 years)		not > 100 000 DKK debt, 1st & 2nd round: documents on financial situation & former projects, 5th & 6th round: turnover > 15 billion DKK, documents on former projects and turbine & foundation facts, nearshore: turnover > 4 billion DKK, documents on former projects	none	price cap nearshore: 70 øre/kWh
France EOLE						
France PPI		20 years normally	depends on the round	fuel supply contract, grid connection & other possible studies, site ownership/rental contract	if too few participants , may be cancelled	
France PV	good	20 years	yes	bidder owner of the building, CO_2 assessment, recycling plan	if too few participants , may be cancelled	none
The NL SDE		15 years		water permit, distance to shore, timetable, financial calculations		
The NL SDE+	very good	technolog y-specific: 5/8/12/15 years	yes	required permits, site owner permission	none	technology-specific
Brazil	OK	hydro 30, wind 20, biomass 15 years	yes	environmental license, grid connection study, 1st deposit 1% of budget, 2nd deposit 10% of budget, extra for wind: new turbines, >12 months wind measurements	none	1st stage: auctioneer sets, 2nd stage: price from 1st stage
Impact on small actors	predictability good, though only predictability does not ensure small actors	no relation	online process helps but not necessa-ry	the fewer the better, simple criteria and low/flexible deposits OK, permits etc. which are anyway needed OK, "extra" work not good	surprisingly no relation	no relation (though in no country very low caps)

	Banding	Geo-graphical restrictions	Evaluation criteria	Deadlines	Penalties
Ger-many	only PV	rules on what kind of area to install PV but no regional rules	price (when many same prices, smaller project win)	18 months	< 6 months delay/location change: -0,3 c/kWh, > 6 months delay: contract cancelled, 50/25 €/kWh payment, own cancellation: 4/2 €/kWh payment
Den-mark	only offshore wind	predefined sites	price, 1st and 2nd round: e.g. project timetable	yes	1st, 2nd & 3rd round: none, 4th round: support reduction if delay with 1st turbine, payment if delay with last turbine, 5th & 6th round: payment if building delay, support reduction if connection delay, nearshore: support reduction if connection delay, payment if cancellation
France EOLE	only wind	regional diversity considered when awarding	price, economic & long term benefits, technical & financial reliability, environmental issues, local authorities' opinion		
France PPI	all technolo-gies have own auctions	regionality defined to some extent	price, in some rounds similar criteria as in EOLE	depends on the technology	support period reduction or payment
France PV	only PV	none	few first rounds: 66 % price, 33 % CO_2 assessment, later price	18 months	support period reduction if delayed
The NL SDE	only offshore wind	none	price	5 years	20 million € payment if delayed/cancelled
The NL SDE+	no (but every technology own prices)	none	price	technology-specific: 18 months to 5 years	payment of 2 % of budget if delayed/cancelled and if budget > 400 million €
Brazil	depends on the round	none	last (2nd) stage: price	auction type specific: 4 months or 1, 3 or 5 years	contract cancelled if delay > 1 year, payment if cancellation
Impact on small actors	to some degree helps, but not necessary	no relation	price only good (though no countries with small actors preferring criteria)	no relation	flexible penalty system good

	Secondary market	Competition level	Winning prices	Realisation rate	Simple/ complex design
Germany	none	high (15-35 % of the bids awarded)	1st round: 8,48-9,43 c/kWh, 2nd: 8,49 c/kWh, 3rd: 8,00 c/kWh (2nd & 3rd round also very low bids)	not available	rather simple
Denmark	none	middle to low, 1-4 bidders/ round	1st round: 6,9 c/kWh, 2nd: 6,7 c/kWh, 3th: 8,5 c/kWh, 4th: 14,1 c/kWh, 5th: 10,3 c/kWh	2nd round project not realised	depends on the round
France EOLE	none		1st round: 5,2 ECU c/kWh	very low: 20 % (70 MW)	
France PPI	none	depends on the round, very high to very low	biomass 2007: 12,81 c/kWh, 2009: 4,5 c/kWh, offshore wind 2011: 22 c/kWh, 2013: 20 c/kWh	depends on the round, poor to good	depends on the round
France PV	none	1st round low because of CO_2 assessment	2012 highest: 23,2 c/kWh, 2013 lowest: 15,3 c/kWh		simple (after CO_2 assessment was left away)
The NL SDE	none	good		only 600 MW awarded because of lack in budget	
The NL SDE+	none	very high (budget exhausted in the first rounds yearly)	the predefined price caps		rather simple
Brazil	yes	very high	very low prices, wind in the recent years even lower than conventional energy	low, many delays: in 2013 70% delayed > 1 year	complex
Impact on small actors	no relation	surprisingly, also in high competition successful small actors when not too much collusion/ strategic bidding	also in relatively low prices successful	not enough data	the simpler the better

	Designed for small actors	Exceptions for small actors	Other support at the same time	Grid issues
Germany	also	no (Germany follows the situation if exceptions needed)	no	no
Denmark	no	no	feed-in tariff (same amount as for onshore wind)	no
France EOLE	no	no	no	no
France PPI	no	no	feed-in tariff main support, auctions complementary	no
France PV	yes	no	no	no
The NL SDE	no	no	no	no
The NL SDE+	also	no	minor tax incentive schemes for non-SDE+ projects	no
Brazil	no	no	no	yes: connection often delayed
Impact on small actors	if specially designed, seems to work, but does not have to be designed keeping in mind small actors	not in use in any of the countries, still successful small actors	better when no other main support methods	no relation